New Scientist

WEEKLY July 11–17, 2020

CORONAVIRUS: SIX MONTHS IN

What we've learned so far about how to tackle it

WEIRD SPACE CIRCLES

Newly discovered objects are like nothing ever seen

THE WEIGHT OF GRAVITY

Rethinking the most mysterious force in the universe

By Claudia de Rham

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Virtual events

The art of statistics

Leading statistician David Spiegelhalter reveals the essential principles we need in order to derive knowledge from data. Thursday 23 July at 6pm BST/1pm EDT and on demand.

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Podcasts

Weekly

Treating people with CRISPR gene editing and evolutionary reasons for the types of world leader. Plus: flying snakes (not on a plane) and nearby habitable exoplanets.

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The day's coronavirus coverage updated at 6pm BST with news, features and interviews.

newscientist.com/coronavirus-latest

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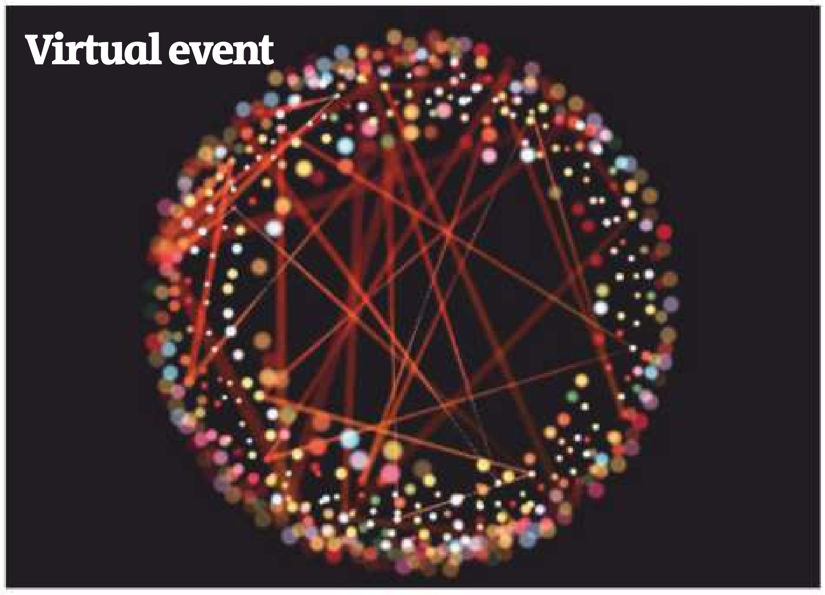

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Number crunching David Spiegelhalter on the dark art of statistics

JAKE SOCHA

Slither and glide How tree snakes wiggle their bodies to fly

S. GARCIA COURNOYER/ALAMY

Bolts from the blue Record-breaking lightning flashes confirmed

A note from the editor

It goes without saying that all awards are nonsense, except for the ones you win. I am therefore very pleased to let you know that *New Scientist* took home the UK's premier magazine gong at last month's Professional Publishers Association (PPA) awards.

We won the top prize, Consumer Magazine Brand of the Year, against the likes of *Vogue* and the *Radio Times*. The PPA said: "The judges were blown away by this incredible story: a hugely successful rejuvenation of an already great brand, powered by excellent editorial for a demanding audience."

Coming as it does after a testing few months, this was a hugely gratifying win. I am especially delighted that this award recognises the fantastic efforts of everyone in the *New Scientist* team, whether in editorial, events, design, marketing, sales or production.

But I am also pleased that the judges singled out you, our "demanding" audience. You are demanding – and rightly so. You keep us on our toes in our efforts to bring you the very best science and technology news. You pull us up when we come short, but are generous with praise when we get things right. For all of that, thank you.

I hope we continue to earn your loyalty in what are likely to be challenging months ahead. You can always write to me directly, by the way, at editor@newscientist.com.

Emily Wilson
New Scientist editor

New Scientist
Podcast

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Press Gazette

The New Scientist Weekly podcast

Episode 24 out Friday 10 July

Our weekly podcast has become the must-listen science show, bringing you the most important, surprising or just plain weird events and discoveries of the week. If you missed the earlier episodes you can still listen in to hear about:

Episode 23
Coronavirus immunity and vaccine implications, evolutionary reasons for the types of world leader and treating people with CRISPR gene editing

Episode 22
Consciousness from the body as well as the brain, record temperatures in the Arctic and long-term symptoms of covid-19

Episode 21
How to prevent future pandemics, how our brains might trigger a hibernation-like state, plus black lives matter and racism in science

Episode 20
Human cryptic mate choice, cracking nuclear fusion and countering coronavirus misinformation

Hosted by *New Scientist*'s Rowan Hooper and Penny Sarchet, new episodes are out each Friday. Follow us on Twitter **@newscientistpod**

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"Easy to use, saves paper, makes my mind dance with ideas."

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"Best app... endless fascinating topics for discussion, and I never fail to learn something new."

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Seek and ye shall find

Our journey of cosmic discovery is only just beginning – thank heavens

INEXPLICABLY regular rings of radio waves have been found in space. The discovery of "Odd Radio Circles" (see page 14) has all those ingredients of mystery, intrigue and wonder that make a classic cosmic yarn, speculation of alien involvement included.

But there is much more to this than just a cute story. Odd Radio Circles are a thrilling reminder of how much more there is left to discover out there – and of how much there is to look forward to.

The find came as part of the Evolutionary Map of the Universe pilot survey, the first stage of a project that aims to increase the number of radio sources we know of in the sky from the current 2.5 million to more than 70 million. It piggybacks on what should eventually become the Square Kilometre Array. This multi-nation project spread over two continents will revolutionise radio astronomy, allowing us to peer back into the "dark ages" of the first billion or so years of the universe's existence, and so understand better how stars, galaxies and black holes formed.

That's not all. The Vera C. Rubin Observatory, previously known as the Large Synoptic Survey Telescope, is due to see first light later this year. Its Legacy Survey of Space and Time aims to map 37 billion heavenly objects over 10 years and answer questions ranging from the nature of dark matter and dark energy to how the Milky Way formed and how much stuff there is out there in the solar system – as well as how much of it might be heading Earth's way. Meanwhile, the LIGO and Virgo gravitational wave observatories are making the detection of ripples in space-time almost routine, opening up a fundamentally new window on the cosmos.

> "Odd Radio Circles aren't just a cute story – they are a thrilling reminder of how much there is left to discover out there"

Gravitational waves, like plenty else out there, are predictions of Einstein's general theory of relativity. A century on, this remains our best large-scale theory of the universe. As theorist Claudia de Rham reminds us in our cover story (see page 30), the search for even better theories to replace it continues too. So hats off to that, to Odd Radio Circles and to all these journeys of cosmic discovery. The situation on Earth may not be so pretty right now, but in the heavens at least, the wonders never cease. ■

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New Scientist
Newsletter

Fix the Planet

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Adam Vaughan

REUTERS/CHARLES PLATIAU

Visitors at the recently reopened Louvre museum in Paris, France

Covid risk or just hot air?

As people return to public buildings, there is disagreement over the risk of airborne spread of the coronavirus, reports **Michael Le Page**

OVER 200 scientists have called for the world to take more precautions against the airborne transmission of the coronavirus. While the virus is known to spread through the air via large droplets produced when people cough or sneeze, they say it can also be spread by smaller droplets known as aerosols that can linger in the air. Preventing this means ventilating buildings and avoiding overcrowding.

"Hand-washing and social distancing are appropriate, but, in our view, insufficient to provide protection from virus-carrying respiratory microdroplets released into the air by infected people," states a letter written by Lidia Morawska at Queensland University of Technology in Australia. It has been signed by 239 researchers (*Clinical Infectious Diseases*, doi.org/gg34zn).

The letter also calls for international bodies such as the World Health Organization (WHO) to acknowledge the possibility of this type of airborne spread and suggests precautions against it.

Morawska and others have made similar calls in recent months, but it is especially important to address the issue now that people in many countries are returning to workplaces, restaurants and pubs, says signatory Julian Tang at the University of Leicester in the UK. Improving ventilation will reduce the risk, he says. "You can't rely on people wearing masks."

The letter has been attacked by some researchers. "I don't think the overall conclusions are correct," says Paul Hunter at the University of East Anglia, UK. "They are potentially damaging."

He says the letter could cause confusion among the public and that taking measures to prevent aerosol spread could give people a false sense of security, making them less likely to take other steps, such as washing their hands.

The WHO uses the term "airborne spread" only for transmission by droplets that are less than 5 micrometres in diameter. These can remain aloft for longer than the larger droplets produced by an infected person coughing or sneezing.

The WHO's position is that there is only a risk of spread of the coronavirus via aerosols when medical procedures such as intubation produce them, but many researchers think it can also be spread by aerosols produced when people talk, laugh or sing.

However, few scientists think that coronavirus aerosols can infect anyone far from the source. "The letter is not arguing for long-range transmission," says signatory Catherine Noakes at the University of Leeds, UK.

> **"Hand-washing and social distancing are appropriate, but, in our view, insufficient to provide protection"**

People are only likely to be infected this way if they are close enough to a person with the coronavirus for long enough to breathe in a large number of virus particles, she says. This is much more likely in poorly ventilated spaces where particles build up.

The main point of contention is what proportion of cases are caused by aerosol spread. "I think there probably is some airborne transmission," says Hunter. "The issue is whether that is important enough to justify additional control measures."

No one knows for sure because it is hard to tell how people get infected. It is usually assumed to be via touch or droplets rather than aerosols, says Morawska.

Tang says the WHO doesn't want to acknowledge airborne transmission of this sort because preventing it involves more expensive and disruptive control measures – such as medical staff wearing N95 masks – that many countries would struggle to afford. However, the letter doesn't call for any changes in hospital practices.

The WHO gave a standard response when asked for comment on the letter: "We are aware of the article and are reviewing its contents with our technical experts." ▮

Daily coronavirus news round-up
Online every weekday at 6pm BST
newscientist.com/coronavirus-latest

Bereavement

Pandemic risks a rise in severe grief

The events around losing loved ones to coronavirus makes death harder to cope with

Alice Klein

SINCE losing her mother to covid-19 in April, Helen Stoba, who lives in Liverpool, UK, has been racked with guilt, anger and confusion. She struggles to focus and has nightmares. "No one truly understands how different the grieving process is at the moment," she says.

Psychiatrists are observing similar emotions in others who have lost loved ones to covid-19. They warn that the unique challenges of coming to terms with these deaths could lead to a rise in a condition known as prolonged grief disorder.

Grief tends to ease with time as people adapt to life without the deceased. But about 10 per cent of bereaved individuals develop prolonged grief disorder – severe, unrelenting grief that lasts for six months or more and makes it difficult to function.

Previous research has found that people are more likely to develop the condition if a death is sudden and unexpected, they are experiencing other stressors or they lack social support.

More people are experiencing these risk factors during the pandemic, since the coronavirus often kills swiftly, many bereaved people have additional stressors, such as the loss of their job, and social structures are undermined.

"Grieving people tend to appreciate a hug, which is impossible when we are required to adhere to physical distancing," says psychologist Lauren Breen at Curtin University in Australia.

Workers carry the coffin of a covid-19 victim in St Petersburg, Russia

ALEXANDER DEMIANCHUK/TASS/ALAMY LIVE NEWS

Many covid-19 deaths also come with extra challenges that could further increase the risk of prolonged grief disorder, says Joseph Goveas, a psychiatrist at the Medical College of Wisconsin. These include not being able to say goodbye in person, restrictions on rituals like washing, kissing or viewing the body and limits on the number of people who can attend funerals. These may all derail the healing process, he says.

Goveas is also seeing high levels of guilt in patients who have lost loved ones to covid-19. "They feel like they didn't do enough or they have survivor's guilt and wonder why they were spared," he says.

It is too soon to know whether covid-19 will cause an epidemic of prolonged grief disorder, since it takes at least six months to diagnose, says Maarten Eisma at the University of Groningen in the Netherlands. But he thinks there is a high risk, since natural disasters tend to increase rates of the condition and covid-19 shares similar features, like causing large numbers of sudden deaths.

Fortunately, there are effective treatments. A talking therapy called complicated grief psychotherapy, for example, has been shown to reduce symptoms of the condition and to work better than antidepressants.

Stoba has found that talking to a bereavement counsellor and joining online support groups have helped.

"Being aware of the risk of developing prolonged grief disorder and accessing timely treatment may aid in mitigating a silent epidemic from happening," says Goveas. ▮

Psychology

Horror movie fans are better at coping with the pandemic

PEOPLE who watch a lot of horror films and those who are curious about unpleasant things seem to be more psychologically resilient to the covid-19 pandemic, a study reveals.

"Horror users tended to have less psychological distress," says Coltan Scrivner at the University of Chicago.

Scrivner and his colleagues asked 310 US volunteers which types of film they liked. The options included horror and "prepper" genres such as post-apocalyptic movies. The volunteers then took personality tests and completed a questionnaire to measure their morbid curiosity: how motivated they were to seek out information about disturbing phenomena.

Alongside this, the volunteers were asked how well they were coping with the covid-19 pandemic – for instance, whether they were experiencing unusually severe negative states like anxiety.

Participants were also asked how well-prepared they had been, such as whether the pandemic's impact had taken them by surprise.

Fans of horror movies were less prone to negative mental states (PsyArXiv, doi.org/d2x7). This "suggested to us, maybe with horror it's about emotion regulation", says Scrivner. Watching scary movies "allows me to give myself the experience of being afraid and then conquering that fear", he says. This may be one underlying reason why people are drawn to scary stories.

The prepper genres, in which society's institutions collapse, were associated with an extra benefit. "We find that same decrease in psychological distress, but you also find an increase in preparedness," says Scrivner.

> "Scary movies allow me to give myself the experience of being afraid and then conquering that fear"

People with high levels of morbid curiosity had a different profile. This trait was linked to an ability to enjoy things despite the pandemic, says Scrivner. "People who scored high in morbid curiosity were no different in the psychological distress, they weren't more or less prepared, but they did exhibit more positive resilience," he says. ▮

Michael Marshall

Why hasn't the UK had a second wave?

Scientists have repeatedly warned of a second surge of covid-19 infections as restrictions ease. Were they wrong, asks **Clare Wilson**

PUBS, restaurants and cafes in England welcomed customers back through their doors on 4 July, sparking warnings of a second wave of covid-19 infections. Yet there have been warnings of another wave since the country began easing restrictions, and one hasn't materialised. Will this time be different?

Scientists on an independent advisory panel on coronavirus called Independent SAGE have repeatedly warned that the relatively swift easing of lockdown restrictions in England risks cases rising again.

On 11 May, people in England were allowed to go outside to exercise multiple times a day and certain groups were encouraged to return to work. June saw the reopening of non-essential shops, certain year groups returning to school and households mixing outside. On Saturday, social distancing guidelines were reduced and numerous indoor hospitality venues reopened.

Speaking at a press briefing last Thursday, England's deputy chief medical officer, Jenny Harries, said a new spike in cases in the UK was a possibility: "A second peak, as in an epidemic peak, another one, is also not ruled out."

England has eased restrictions faster than the rest of the UK and much of Europe. The government says the pace of change is justified because infections in the UK have been declining since April, when they peaked at over 8000 cases a day.

One explanation for a lack of a second wave that can be ruled out is herd immunity, whereby enough people have become invulnerable to the virus that it can no longer spread freely. The herd immunity level for this coronavirus has been estimated at 60 per cent of a population, but studies from around the world suggest that just 1 to 10 per cent of people have antibodies to the virus, which suggests a previous infection.

DANIEL LEAL-OLIVAS/AFP VIA GETTY IMAGES

Customers return to bars in Soho, London, after they reopened on 4 July

"It doesn't seem anything like enough of us have been exposed," says Mark Woolhouse at the University of Edinburgh, UK. We also don't know how long people who have antibodies are protected from reinfection.

The arrival of summer in the northern hemisphere may have helped to quash infections for now. Some evidence suggests that, as with certain other respiratory viruses, coronaviruses stay viable on surfaces for longer when the air is cooler and less humid, and some studies have found a link between new infections and lower humidity. However, it is still unclear whether the coronavirus will have a seasonal cycle like flu.

Warm weather also encourages people to spend more time outdoors, where the virus is more likely to be damaged by sunlight or drift away on a breeze. One study in China found that 98 per cent of super-spreading events, where transmission is disproportionately high compared with normal transmission rates, happened indoors. "Climate may or may not be a factor, but we know that spreading is less easy outdoors," says Gabriel Scally, a member of Independent SAGE.

There may be other factors that are keeping case numbers down. Around half of UK deaths related to coronavirus have been care home residents, but such settings now have better infection control practices in place.

Another possible explanation is that people are continuing with precautionary behaviours. A poll of more than 2000 UK residents compared people's attitudes towards lockdown rules at the start of April with those at the end of May and found compliance remained high.

"People were still sticking pretty uniformly to the social distancing measures," says Bobby Duffy at King's College London, who was involved in the study. "The theme is incredible caution and a strong sense of the risks involved among the majority of the population."

It has also only been a few weeks since people really started to go out more. "It takes time to build up the cases," says Scally. A second wave hasn't happened yet, but that doesn't mean those who predicted one have been proven wrong.

1-10%

of people have antibodies to the virus, suggesting prior infection

Several countries have had a resurgence of cases in recent weeks after easing restrictions. Israel has said it is facing a second wave after reporting almost 1000 new cases on 5 July, and has reimposed restrictions. South Korea has had several new clusters of infections, stemming from nightclubs and offices. Restrictions have also been reimposed in parts of Spain. And several US states, including Texas, have reversed the easing of restrictions in bars and restaurants.

"Virtually every place that starts to loosen up and where social distancing diminishes, you start to see outbreaks appear," says Anthony Costello, also of Independent SAGE. "The question is, do they coalesce into a full blown second surge."

There are hints that things could be changing in the UK. Latest figures from the Office for National Statistics show that the declining incidence rates in England seen until early June have now levelled off. There is also a local outbreak in the city of Leicester, which has gone back into lockdown.

It is vital any new clusters in the UK trigger similar local lockdowns, says Adam Kleczkowski at the University of Strathclyde in Glasgow, UK. "We are much more prepared now and we understand the dynamics of the virus more than three months ago." ■

National strategies

How to stop the virus

Six months into the global outbreak, we are learning what measures are most effective at halting the coronavirus, reports **Jessica Hamzelou**

SINCE the first reports of the novel coronavirus, the list of known symptoms has changed, as has our understanding of what the virus does to the body. Health advice, for both governments and individuals, has evolved, too. And although some countries claim to have virtually eliminated the virus, others are only now seeing cases beginning to spike and some are seeing what looks like a "second wave" of infections. What can we learn from the countries that got it right – and those that got it so very wrong?

Fast action

One major early fumble was the incorrect assumption that the virus was like the flu. Many nations already had a plan in place for dealing with a pandemic flu. "It inhibited their ability to think about how to respond to another virus," says Jennifer Nuzzo at Johns Hopkins University in Maryland.

The coronavirus required a different response, says Michael Baker at the University of Otago in Wellington, who advised the New Zealand government on the country's covid-19 response. Flu typically has an incubation period – the time between someone becoming infected and showing symptoms – of around one to two days. This makes it extremely difficult to trace the contacts of an infected person before they get sick themselves.

The coronavirus, on the other hand, appears to have an incubation period of about five to six days, but potentially several weeks. "It means that it's a slower moving wave and there are more opportunities to use contact tracing and isolation and quarantine," says Baker. "We know that's the case because [the] SARS [coronavirus] was contained and eliminated with those traditional measures."

In addition, while flu can "sweep through a population in a matter of weeks", he says, the coronavirus can stick around for much longer and can have lasting health effects for those who survive covid-19. This is one reason why the idea of waiting to achieve herd immunity rather than taking action to limit the impact of the virus – a strategy the UK and Swedish governments initially considered – was widely dismissed by the scientific community.

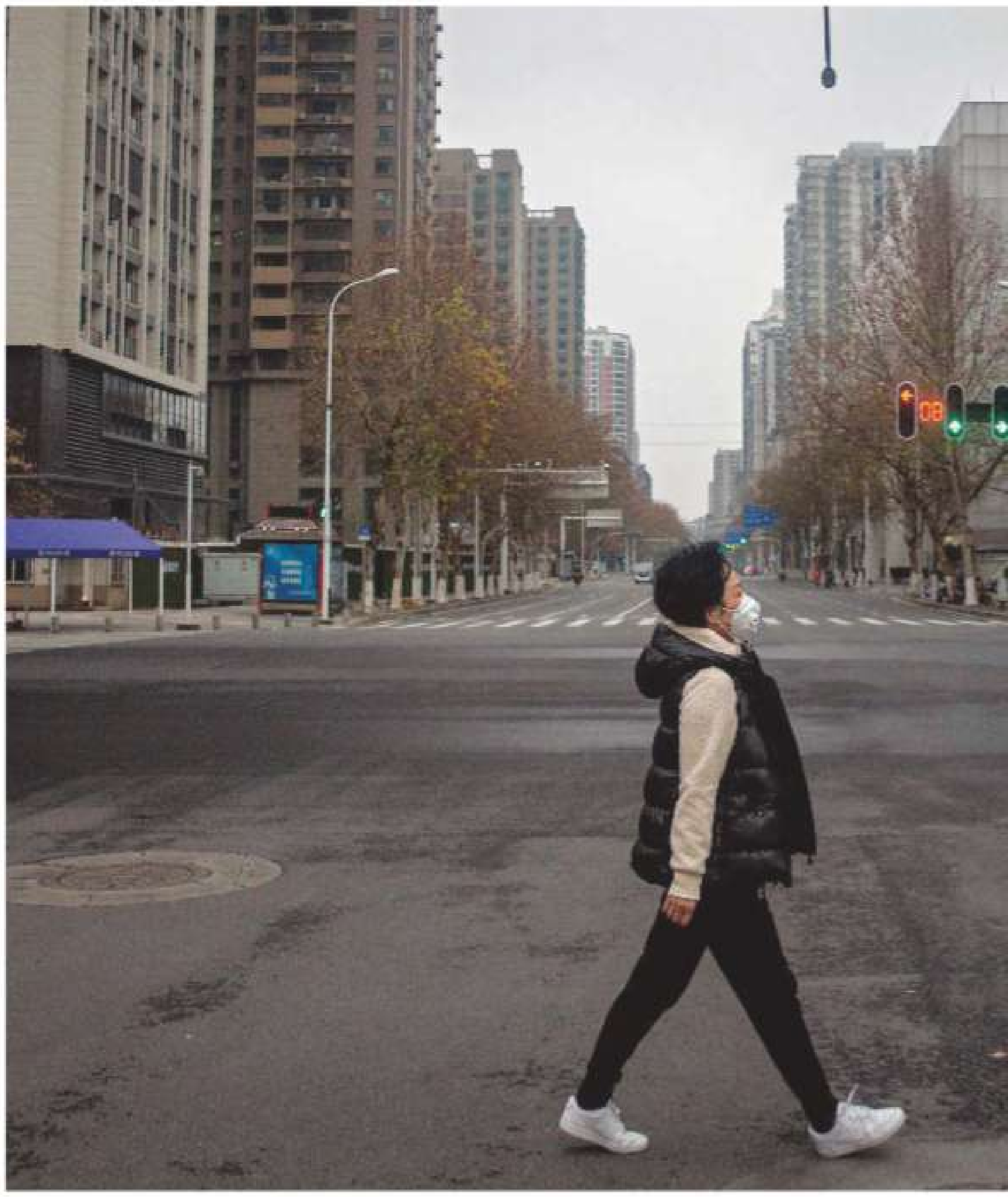
"I think we've seen that the results can be devastating when you just let things go"

Today, the UK has the highest number of recorded coronavirus cases in western Europe, probably in part due to the UK government's delayed response to the outbreak. One factor that unites the nations that have done a better job at limiting case numbers is a quick initial response.

"In countries like China, South Korea, Japan, the initial response was quite rapid, so the containment phase worked really well for them," says Rajiv Chowdhury at the University of Cambridge. By quickly identifying new cases and where they were coming from, these countries stood a much better chance of interrupting the ongoing transmission of the virus, he says.

Well-timed lockdowns

Another strategy that appears to have been successful was the use of lockdowns: imposing restrictions on movement to contain the spread of disease. A lack of such constraints in Sweden has been widely blamed for the country's level of cases, which far exceeds those of neighbouring countries.


STRINGER/GETTY IMAGES

A woman walks in Wuhan, China, during lockdown in January

"When you just let things go, and don't implement any control measures… I think we've seen that the results can be devastating," says Susy Hota at the University Health Network in Canada.

Lockdown rules have varied widely worldwide, but implementing restrictions early on worked well for many countries, including China and New Zealand.

New Zealand's lockdown was particularly strict: schools, universities and almost all businesses were shut, and people could only leave their homes for essential reasons. Such measures succeeded in lowering the R number – the average number of people one person with the virus will go on to infect – from around 2 to around 0.5 within five weeks, says Baker.

Modelling has suggested that implementing lockdown just a week earlier in the UK could have avoided 20,000 deaths.

But lockdowns don't necessarily work the same way in low and middle-income countries, where it can be much harder for people living in low-quality housing in densely populated areas to stay home and lose out on income,

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says Chowdhury. Because such nations may only be able to sustain short-term lockdowns, the timing of these restrictions is crucial, he says.

Chowdhury points out that many countries in South Asia and Central and South America imposed lockdowns when European ones did. At that point, cases were soaring in Europe, while there were few in many low-income nations. In theory, it makes sense to introduce lockdown while cases are still low, says Chowdhury. But because of the difficulties in enforcing restrictions, case numbers continued to rise.

Cases are now climbing in many countries where governments have eased restrictions that have become economically unsustainable. “That’s a trend I see in many countries in Latin America, South-East Asia and Africa,” says Chowdhury.

These and other regions are fast becoming the next coronavirus hotspots. Many people in Bangladesh, for example, found it hard to comply with lockdown restrictions, with almost three-quarters of those in urban areas losing their main source of income. In Brazil, mixed messaging from the government weakened the impact of lockdown. The virus is currently spreading significantly in both countries.

Alternative approaches may work better in some countries, says Chowdhury. The World Health Organization (WHO) has recommended that Pakistan, which has also experienced a spike in cases, impose a rolling two-week-on, two-week-off lockdown, for instance. More localised lockdowns could also be effective. This approach has already been adopted in a number of other countries, including in the UK city of Leicester.

Travel restrictions

Lockdown alone isn’t enough, however. Since the beginning of the outbreak, the value of testing people for the virus, tracing their contacts and encouraging them to isolate themselves has become clear.

“It has proven to be important, not just for helping to interrupt transmission… but also for us to better understand where transmission is occurring, so we can have targeted efforts to protect people in those environments,” says Nuzzo.

Part of New Zealand’s success was down to the strengthening of test-and-trace capacities, for example. “New Zealand was not the world leader in this,” says Baker. “We learned from the Asian experience.” Specifically, Baker and his colleagues followed what had worked in places like Taiwan, which has reported fewer than 10 deaths to date.

Both New Zealand and Taiwan enforced border controls early on in the outbreak, restricting the arrival of travellers who might bring the virus in with them. Travel restrictions also worked well for Nepal and Sri Lanka, says Chowdhury.

Some countries that didn’t impose such restrictions appear to have suffered as a result. “That has been a key factor in how quickly we saw the local epidemic become a pandemic in Bangladesh,” says Chowdhury. When outbreaks were hitting Europe and the Middle East, Bangladeshis in these regions boarded flights back to the country. “People were scared and wanted to go to their home country, and a good proportion were potentially carrying the virus,” says Chowdhury. “It was impossible for the local government to screen so many people so suddenly and, as a result, they lost control.”

People get tested for covid-19 in a hospital car park in South Korea

LEE YOUNG-HO/SIPA USA/PA IMAGES

The first UK outbreaks are thought to have been triggered by people returning from ski holidays in Italy and Austria, and cases also came from China, says Patricia Schlagenhauf at the University of Zurich in Switzerland. “It’s obvious that travel does contribute a lot to the spread of the virus,” she says.

20,000
UK deaths might have been avoided by a swifter lockdown

However, at the start of the pandemic, the WHO made a point of not recommending that international travellers be screened for infections or travel be restricted in any way. “Later, they did advise against unnecessary travel,” says Schlagenhauf.

But travel restrictions and bans are hard to implement and people can always find ways around them, says Hota. Such restrictions aren’t always the best use of resources, either, especially for bigger nations and those that aren’t islands, where the challenge is much greater, says Nuzzo. She highlights the experiences of the US, which banned most non-residents from arriving from China in February. “But there are a lot of people travelling from China to the United States anyway because they are residents of the US,” says Nuzzo.

The public health resources dedicated to managing this small pool of people could have been better implemented elsewhere, says Nuzzo. “I had a colleague at a large city health department who said that they had two returning travellers from China who they needed to put into

›

quarantine," she recalls. "They had 33 staff dedicated to finding them a hotel, monitoring them, making sure their safety was ensured and making sure they didn't leave," she says.

"It ate up all of [the] resources to do things like expand hospital capacity and protect nursing homes and expand laboratory testing," says Nuzzo. "There was a lot of stuff the US needed to be doing in January, February and early March that [it] just didn't do."

Blocking travel from China didn't help places like New York. The city's huge outbreak is thought to have been triggered by travellers bringing the virus from Europe, says Nuzzo.

Face masks and coverings

A better understanding of how the virus spreads is also changing the way we try to tackle its spread. We have learned, for instance, that people without symptoms can spread the virus. This appears to be true of both those who later go on to become unwell and those who never develop any symptoms.

And while we still don't know exactly how important this mode of transmission is for the overall spread of coronavirus, the finding has helped to shift the advice on mask wearing for the public. In April, the WHO advised that people with symptoms should wear a face covering, but that there was no evidence to support mass mask wearing in the wider community.

The organisation changed its position in June, and currently recommends that people over 60 and those with underlying health conditions don a medical-grade mask in settings where they are unable to keep their distance from others. Non-medical masks are also recommended for anyone visiting indoor public settings, such as shops, schools and public transport, as well as those living in cramped conditions, or spending time in areas where there is widespread transmission or where physical distancing is impossible.

Even now, there are no robust, randomised, controlled trials to show that mask wearing in the community slows the virus's transmission. Sceptics caution that cloth masks vary in their ability to limit the spread of infectious particles – and none will completely prevent transmission. There are also concerns that, outside clinical settings, face masks are often improperly used. Many users continue to touch their faces while wearing face coverings, wear them below their noses or fail to wash them between uses, for example, rendering them much less effective.

> "Quarantining travellers from China ate up all the US's resources. There was a lot it just couldn't do"

Still, scientific consensus has swung in the past few months. Now, most scientists will argue that, as the use of face masks is supported by a handful of small, weak studies, and they don't do any harm, they are worth using, at least in places where it is hard to keep away from other people. "There's no reason not to use them," says Nuzzo.

Despite the lessons learned, many countries remain a long way from eliminating the virus, and a mix of strategies will be required. "I think the goal is to keep the case numbers as low as possible until we get a vaccine," says Nuzzo. ▮

What we still don't know about the virus's spread

Despite all we have learned about how the coronavirus is transmitted and how best to contain it, plenty of questions remain unanswered.

Mass gatherings

The role that mass gatherings play in the virus's spread is still unclear. A football match in Milan, Italy, in February is thought to have contributed to the particularly large outbreak that followed in the area. Outbreaks have also been linked to big social gatherings.

Modelling studies suggest that mass gatherings can act as so-called superspreader events. Yet we still don't know how important these events have been in the spread of coronavirus, says Rajiv Chowdhury at the University of Cambridge.

Superspreaders

More generally, the role of superspreaders – people who infect a disproportionate number of others – remains unknown. That is partly because researchers and governments have tended to focus on the R number, which indicates the virus's ability to spread, instead of the K number, which illustrates how much of that spread is due to what proportion of people.

The K number might suggest, for example, that 10 per cent of people are responsible for 80 per cent of infections. "It sheds light on the variation behind R and how much a disease relies on mass gatherings," says Chowdhury. "It's something we need to look at."

MARCIO MACHADO/EURASIA SPORT IMAGES/GETTY IMAGES

Football fans in Milan enjoy a game that was later blamed in part for the local outbreak

Indoor locations

We have learned that being close to someone, indoors, plays a significant role in spreading the coronavirus. But how well venues can manage this risk is still being investigated.

Bars, nightclubs, ski resorts and cruise ships have all been linked to outbreaks. People won't be covering their faces when eating or drinking and they get close to each other to speak when loud music is playing. Alcohol is likely to lower inhibitions regarding social distancing, too.

Schools

We have learned that only a tiny percentage of children appear to experience severe cases of covid-19, but children may still pass the virus on to adults. The evidence from reopening schools so far is mixed. There have been encouraging signs in Europe, but some schools in Israel have had to be closed again after hundreds of students and staff have tested positive.

18+

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Astronomy

Circles in space are like nothing we've ever seen

Jason Arunn Murugesu

The ASKAP radio telescope in Western Australia

CSIRO

MYSTERIOUS circles of radio waves found in space have left astronomers scratching their heads, with no idea how they formed or even how big or far away they are. They don't seem to match anything that has been seen in space before, so researchers have dubbed them Odd Radio Circles, or ORCs.

Ray Norris at Western Sydney University, Australia, and his colleagues found these unexplained objects using the Australian Square Kilometre Array Pathfinder (ASKAP) telescope, which was completed in 2018. The discovery was made as part of a project aiming to take a census of all the radio sources in the sky (arxiv.org/abs/2006.14805).

The researchers spotted four circles in total: three using ASKAP and one when searching archival data from a different telescope. The team suggests that previous surveys had failed to observe these circles as their telescopes were unable to detect such faint radio waves.

"Whenever we have new search capabilities that come online, we can expect to discover the unexpected," says Jason Wright at Pennsylvania State University.

We know little about the ORCs at present. They are symmetrical and their edges are brighter than their interiors. Two have a galaxy in the middle, while the other two don't.

We can't even tell how big or far away they are, as the team was unable to associate them with objects of a known distance. Two appear close together in the sky, but their physical distance from each other is unknown.

"They don't match anything else in space, so researchers have dubbed them Odd Radio Circles"

It isn't clear if all four objects have a similar origin. So far, the researchers have no explanation for what they are. However, they were able to confirm that the objects aren't just artefacts of the ASKAP telescope by observing them through other instruments.

"I think this paper does a really good job of running through all the possibilities of what they could be, or at least everything they can think of – including whether they're not real," says Wright.

The team says the ORCs most closely resemble supernova remnants, the material and energy released when stars explode.

But Mikako Matsuura at Cardiff University, UK, says that is unlikely to be the answer. "We know how many stars there are, due to past radio surveys, so we know approximately how many remnants from star explosions should be found too," she says.

Norris and his colleagues note that there are only 350 or so confirmed supernova remnants in our galaxy and the likelihood of finding three of them in the ASKAP survey is 0.02 per cent.

Another explanation is that the objects are simply galaxies in the shape of circles, known as ring galaxies. Such galaxies are usually easy to observe with optical telescopes, but the ORCs only appear in radio.

One possibility the team didn't consider is whether the ORCs could be caused by aliens – but Wright says that is unlikely. "I can't think of any reason."

To figure out what these objects are, we need to discover more of them, says Wright. "If these findings are as interesting as they seem to be, then people will use other telescope arrays to go looking for them," he says, or look for more in archival data. "Once you have a lot of them, you can then start collecting clues." ▮

Neuroscience

A sugary diet may boost bacteria and impair memories

Jessica Hamzelou

DIETS affect gut bacteria – and the microbes may, in turn, influence brain function by changing how genes are expressed in areas important for memory, a study in rats suggests.

Scott Kanoski at the University of Southern California and his colleagues fed one group of young rats a high-sugar diet, while a separate group of rats were given standard chow.

Around a month later, the team tested the rats' ability to tell whether or not they had seen an item before. This type of memory is thought to rely on a brain structure called the hippocampus.

The rats on the high-sugar diet performed significantly worse than those on the healthy diet.

Analysis of the animals' faeces found that the guts of the sugar-fed rats contained higher levels of several types of bacteria. Rats with greater amounts of *Parabacteroides* bacteria performed worst on the memory task.

To find out if *Parabacteroides* bacteria might be influencing brain function, Kanoski's team delivered the bacteria directly to the guts of a separate group of rats that had been fed a cocktail of antibiotics to kill off previous communities of bacteria.

These rats performed worse at the memory tasks compared with rats that had just been treated with antibiotics.

The hippocampi of the rats also appeared to express genes differently. This brain region had a pattern of gene expression that suggested alterations in the way certain groups of neurons fired in both the rats that were fed sugar and those treated with *Parabacteroides* compared with the other rats (bioRxiv, doi.org/d2xv).

The hope is that researchers will eventually discover probiotics that can be used to improve brain functioning in humans. ▮

Archaeology

Stone tools or sculptures?

Mysterious flint artefacts may be crude depictions of humans

Michael Marshall

MORE than 100 distinctive flint artefacts from a Stone Age village in Jordan may be figurines of people used in funeral rituals, according to a team of archaeologists. However, other researchers aren't convinced that the objects represent people at all.

Since 2014, Juan José Ibáñez at the Milá and Fontanals Institution for Humanities Research in Spain and his colleagues have been excavating a site called Kharaysin in Jordan. It was occupied from around 9000 BC until at least 7000 BC. At this time, people who were previously hunter-gatherers were taking up settled farming. Kharaysin is one of the oldest examples of a village where people built houses and lived year-round.

"We were excavating funerary areas, a cemetery," says Ibáñez. This is where the researchers found the flint objects, each with the same distinctive shape and with two pairs of notches carved into it on either side.

"We know very well the tools that are made at that period," says Ibáñez. These artefacts didn't look like any of them.

The objects don't seem to have been used as tools, as they show no signs of wear from use. This suggests they were decorative or symbolic, says Ibáñez.

When a team member first proposed that the artefacts were figurines representing humans, "we were kind of sceptical", says Ibáñez. However, the team has since become convinced that they are depictions of people, albeit crude ones. "They made two notches in one side, one representing the neck probably and the other the hip," says Ibáñez (*Antiquity*, DOI: 10.15184/aqy.2020.78).

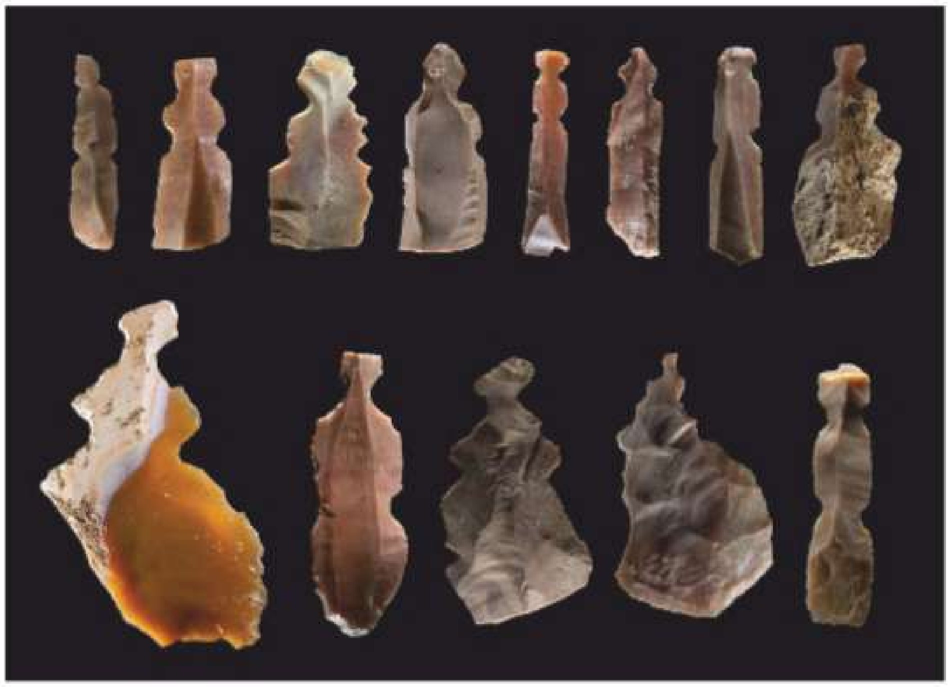
"This is an intriguing hypothesis, but humans are very good at seeing faces in natural objects," says April Nowell at the University of Victoria in Canada. "That is why there are so many stories about the man in the moon, and why every now and again people see Jesus in a piece of toast. If someone showed you that photograph of the 'figurines' without knowing the subject of the paper, you would most likely have said that this is a photograph of stone tools."

It is "very possible" that the artefacts are figurines, but "they might not represent humans at all", says Allison Tripp at Chaffey College in California. "What I think is certain is that they are a form of symbolic communication," she says.

For Ibáñez, the fact that the artefacts were only found in the cemetery suggests that people used them in funerary rituals. At this time, bodies were buried in pits, but they were later dug up and certain bones were removed and reburied elsewhere.

This suggests a reverence for ancestors and perhaps a desire to consult with them through rituals, says Ibáñez. He says the figurines may have played a role in this. ▮

These flint objects found in Jordan may be human figurines



KHARAYSIN ARCHAEOLOGICAL TEAM

Environment

Windows filled with water could help climate fight

WINDOWS containing water could cut energy use in buildings in much of the world, according to a trial of the technology.

Double and triple-glazed windows often use argon gas in the space between panes. This limits heat getting in or out of buildings, helping keep them warmer in colder weather or cooler on hotter days.

Instead of this gas, Matyas Gutai at Loughborough University, UK, and Abolfazl Kheybari at the University of Kaiserslautern, Germany, turned to water for its ability to absorb the heat from the sun. Once warmed by the sun – a process called solar gain – the water is then used to produce hot water or for heating, saving energy.

With data from two prototype buildings with the windows – in Hungary and Thailand – the researchers used computer programs to simulate how much energy the technology would save in 13 towns and cities, including Beijing and New York. The locations were chosen to represent the world's main climatic regions. The windows outperformed conventional glazing in all spots but the chilly Falkland Islands in the south Atlantic.

Looking at the total electricity and space-heating demand of the buildings, the simulation showed that energy use in those with the water windows was 54 to 72 per cent below that of buildings with double glazing, and 34 to 61 per cent less than that of those with triple glazing. The comparisons were made with conventional windows meeting high German standards (*Energy and Buildings*, doi.org/d2xq).

Gutai hopes to launch a spin-off company selling water windows for conservatories next year.

Alastair Mant at the UK Green Building Council welcomes the approach and says we need to embrace buildings that look and operate differently. "Water-filled glass may well have a role" in helping meet future net-zero carbon building standards, he says. ▮

Adam Vaughan

72%

Potential energy savings of water windows over double glazing

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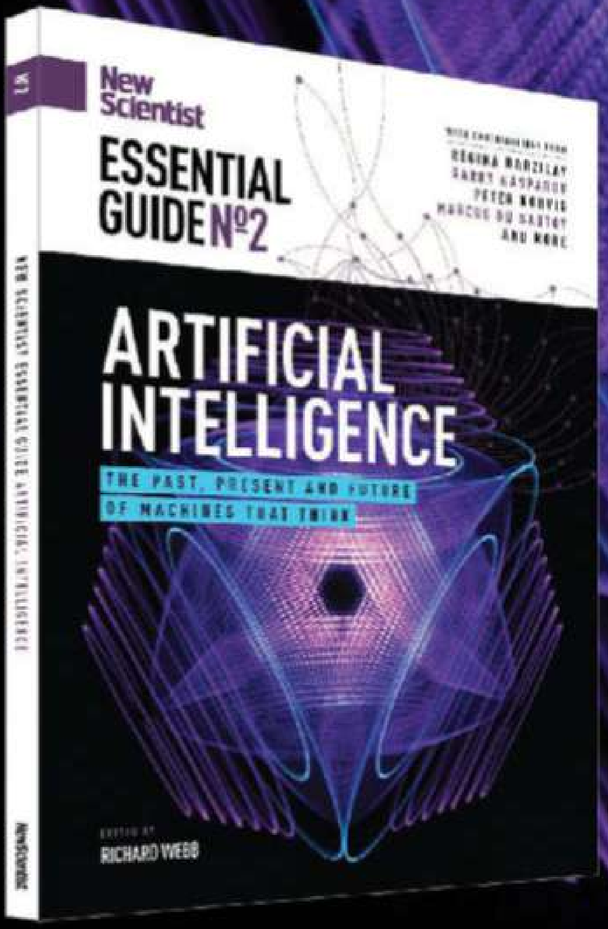

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Archaeology

Blackbeard may have crashed his ship on purpose

Colin Barras

QUEEN Anne's Revenge, the ship that helped the pirate Blackbeard gain fame and fortune, was in poor shape and prone to leaking, a new analysis has revealed. The discovery could explain the vessel's fate, as Blackbeard may have deliberately run it aground to avoid the headache of keeping it afloat.

We know little about the early life of Blackbeard, whose real name was Edward Teach. One of his most successful acts of piracy came in May 1718, when he used his pirate flotilla to blockade the entrance to the port of Charles Town (now Charleston) in South Carolina and ransomed the locals.

At the head of Blackbeard's small fleet was Queen Anne's Revenge, formerly a French slave ship that the pirates captured in November 1717. But the flagship vessel may have been difficult to maintain.

Jeremy Borrelli at East Carolina University in Greenville has analysed lead sheets and strips from the ship, which was rediscovered on the seabed off the coast of North Carolina in 1996. The lead artefacts appear to be patches used to help seal holes in the ship's wooden hull. Given there are 86 of them – the largest almost 1 metre long and 23 centimetres wide – it seems that the hull must have been patched extensively (The International Journal of Nautical Archaeology, doi.org/d2xw).

"Only 60 per cent of the site has been excavated to date, so if more lead material is found in the forward portion of the wreck, then it would be clearer that the entire ship had issues," says Borrelli.

He suggests Blackbeard may have come to realise that the ship required a lot of maintenance. In 1718, it ran aground and the pirates abandoned it. Borrelli speculates that Blackbeard may have crashed the ship deliberately as it was no longer serviceable.

Environment

Drug cartels fuelling loss of tropical forests

Andrew Wright

CARLOS ALONZO/AFP VIA GETTY IMAGES

Deforestation near Melchor de Mencos in Guatemala

DRUG traffickers in Central America may be responsible for vast swathes of deforestation in Guatemala, according to a new analysis. This is being caused by "narco-ranching", in which criminals launder cash by buying land and cattle, then selling the meat for money that can't be traced to drug activity.

"This is the first attempt to quantify the role narco-cattle ranching plays in the deforestation happening in the Maya Biosphere Reserve," says Jennifer Devine at Texas State University.

She and her colleagues analysed 4500 aerial images of deforested areas in the 2.1 million-hectare Maya Biosphere Reserve in Petén, Guatemala, which covers one-fifth of the country's total land area, to determine what had caused the loss. They found evidence of large-scale cattle ranching in 87 per cent of the images in a key part of the reserve, Laguna del Tigre National Park (*Land Use Policy*, doi.org/d2xr).

Liza Grandia at the University of California, Davis, who has worked in Petén for 27 years, says "cattle culture" has been in the region since the 1960s, when massive ranches were encouraged by the national government.

"It wasn't really until 2002 or 2003 that narco-ranchers entered the area as the new villain," she says. "It was the normality of cattle ranching that really allowed the narcos to move in so swiftly and cloak themselves as an average agribusiness."

2.1m

The area of Guatemala's Maya Biosphere Reserve in hectares

Devine and her team conducted more than 100 interviews with people living in and around the reserve to understand how to identify areas deforested by narco-ranching. Such areas feature large clearings of dozens of hectares of land that are set out with straight lines, rectangular plots and even tractor marks.

She says they can't definitively say that the deforestation was funded by drug traffickers, but other small-scale farmers, or *campesinos*, tend to grow food crops, not just pasture, and have smaller overall plots.

David Wrathall at Oregon State University says narco-ranching happens wherever there is a lot of illegal money passing through forested frontiers. He says that, while *campesinos* have long been scapegoats for deforestation, local people have been shown to be the solution to stopping the destruction of nature reserves.

For example, the Association of Forest Communities of Petén (ACOFOP) manages concessions granted to indigenous people and peasant farmers in 1990 to sustainably harvest timber and other forest products. Erick Cuellar, ACOFOP's deputy director, says the land that is part of these concessions has virtually no deforestation compared with national parks.

Marcia Macedo at Woods Hole Research Center in Massachusetts, who studies the Amazon, says that although narco-ranching doesn't appear to be a major driver of deforestation across the whole of the Amazon, studies like the Guatemala one can be a powerful tool to curb such activity.

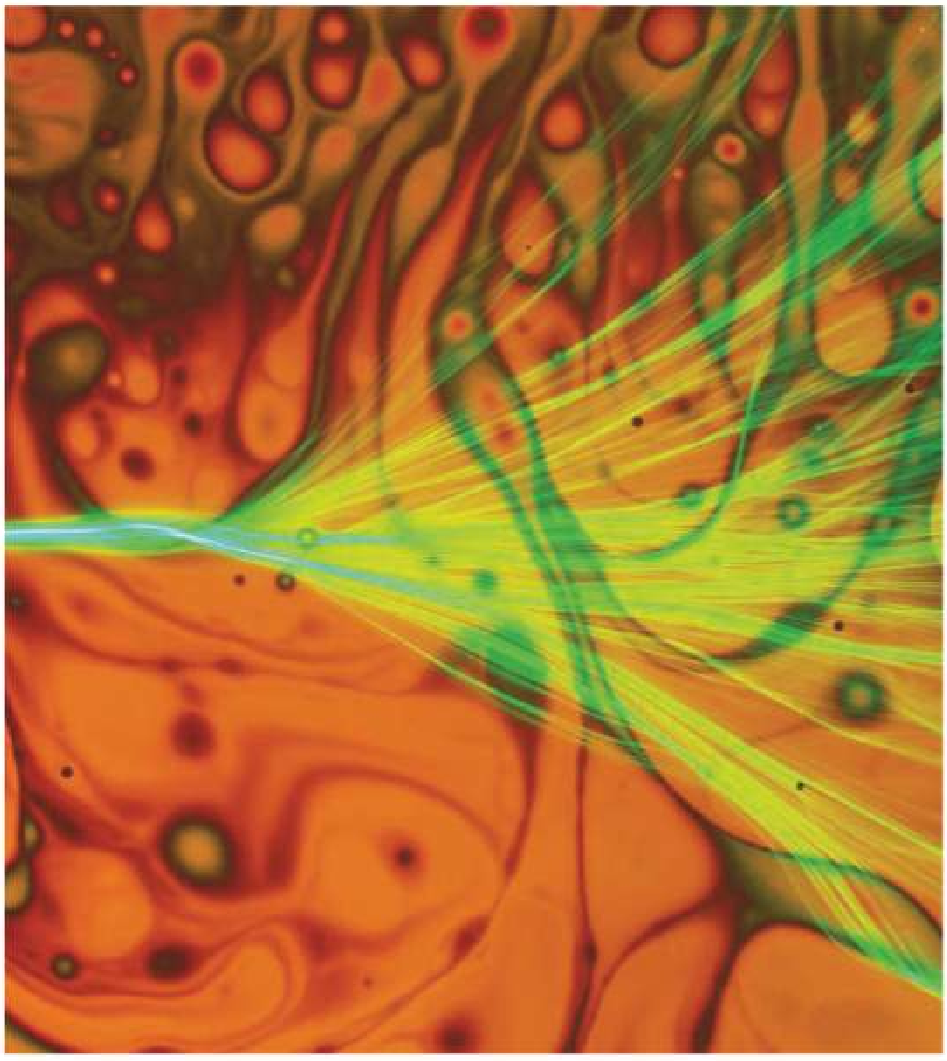
"They can provide objective evidence of what is happening on the ground, prevent false narratives from taking hold and keep voting citizens and the international community informed," she says.

Animal behaviour

Sparrows ditch old songs for new tune

WHITE-throated sparrows (*Zonotrichia albicollis*) normally end their songs with repeated triplet notes, but a song ending in repeated double notes has been sweeping through Canada.

Recordings show that the new style arose in a population in western Canada between the 1950s and 2000, but it has since been heard as far as 3000 kilometres to the east. New songs often arise in isolated populations because there are fewer adult birds for youngsters to learn from, says Ken Otter at the University of Northern British Columbia, who investigated the phenomenon with his colleagues. But it is surprising that the song has spread so widely, he says, because normally males conform to local fashion (*Current Biology*, doi.org/d2vm). **Michael Marshall**



ANATOLY PATSYK, URI SIVAN, MORDECHAI SEGEV & MIGUEL A. BANDRES

Environment

European tree felling grows by 49 per cent

BETWEEN 2016 and 2018, there was a big rise in the area of forest felled in countries across Europe.

Grégory Duveiller at the European Commission's Joint Research Centre in Ispra, Italy, and his colleagues analysed satellite images of the amount of forest cover and area of trees cut down between 2004 and 2018 across 26 European Union countries.

The images suggest that the forest area harvested each year between 2016 and 2018 was 49 per cent higher than that harvested annually between 2011 and 2015. Sweden and Finland accounted for more than half of the total increase (*Nature*, doi.org/d2v3).

These countries have large forestry-related industries, says Duveiller. Another possible explanation for the surge is increased demand for wood-based products. **Donna Lu**

Physics

Soap bubbles split light into otherworldly streams

WHEN a laser beam shines through a membrane made of household soap, it branches in a strange and unexpected way that could help us study the curvature of space-time. This branching behaviour has been observed in several types of wave, but never before in visible light.

Mordechai Segev at the Technion-Israel Institute of Technology in Haifa and his colleagues fired a laser across a membrane made of soap, similar to a soap bubble you would see when washing dishes, to observe visible light branching for the first time.

The soap membrane had random variations in its thickness, so the team expected the laser beam to separate into disordered speckles.

Instead, the changes in thickness in the soap membrane split the light into channels like a river dividing into many streams, and each of those channels of light continued propagating before eventually splitting into yet more streams. This happened both on flat and curved soap membranes. "No one predicted this to happen," says Segev. "It was a complete surprise."

As the molecules in the soap membrane exerted force on the light, the light also exerted force on the molecules, moving them slightly (*Nature*, doi.org/d2v4). By changing the intensity of the light, Segev says it should be possible to change that force over time. "Imagine that you can control the flow of a fluid by controlling the light passed through it," he says.

Firing light through curved soap bubbles could also help us understand how light flows through space-time, which general relativity says is curved because of massive objects stretching the fabric of space and time. **Leah Crane**

Really brief

CARLOS VILLOCH,MAGICSEA.COM/ALAMY

Warming seas could kill many fish

Fish are at a far greater risk from climate change than previously thought. In a worst-case scenario of 5°C of global warming, up to 60 per cent of fish species around the world would be unable to cope with temperatures in their current geographical range by 2100 (*Science*, doi.org/d2xm).

New form of carbon is a better diamond

Diamond, one of the hardest known materials, could have a rival. A new theoretical form of carbon called pentadiamond is just as hard as the gemstone but as light as pencil graphite, and could theoretically be used for storing gas (*Physical Review Letters*, doi.org/d2xn)

Spider silk can be used to make a lens

Covering a strand of spider silk in wax and then dripping transparent resin over it makes the resin form a dome that dangles off the fibre. If you bake the whole structure in an ultraviolet oven to set it, it creates lenses that are just a few micrometres across (*Journal of Applied Physics*, doi.org/d2xp)

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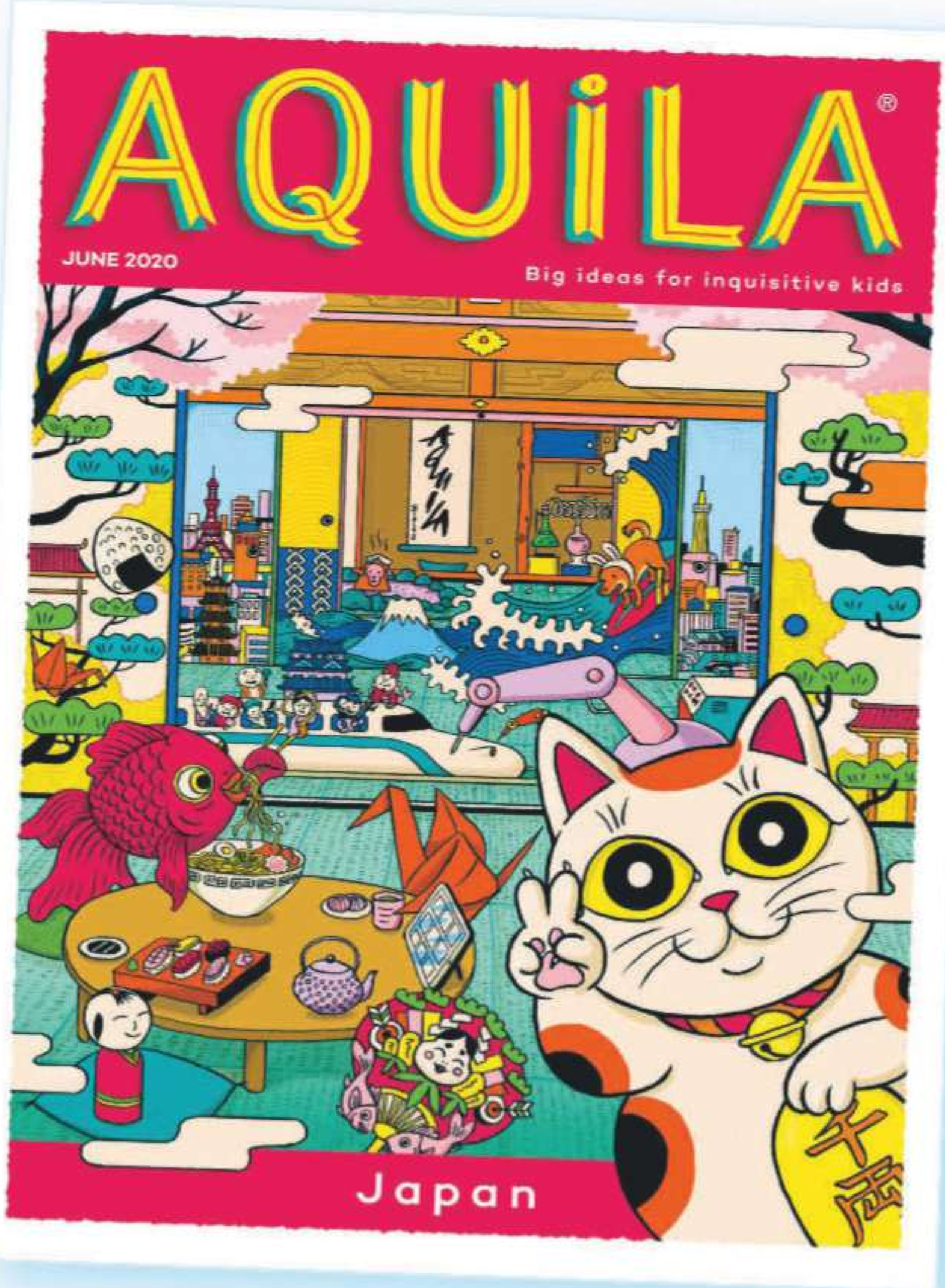

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> RICHARD ROBINSON – BRIGHTON SCIENCE FESTIVAL

Welcome to our Signal Boost project. In these difficult times, we are offering charitable organisations the chance to take out a page in *New Scientist*, free of charge, so that they can get their message out to a global audience. Today, a message from **Wild Futures**

Emergency appeal. Can you help?

Wild Futures is the UK primate welfare and conservation charity, rescuing, campaigning, educating and providing sanctuary to primates in need.

Sixty percent of all primate species face extinction due to human activity; habitat loss, climate change, the bush meat and primate pet trades all contribute to this challenge to their survival.

Founded in 1964, The Wild Futures Monkey Sanctuary in Cornwall, UK, was the first of its kind in the world. Our innovative welfare management practices, exceptional levels of care for monkeys traumatised by the primate pet trade and our internationally recognised training and education programmes mean that our sanctuary is the only one in Europe to be accredited by the Global Federation of Animal Sanctuaries. The charity's commitment to education and skill-sharing is reflected in our board membership of the European Alliance of Rescue Centres and Sanctuaries (EARS).

Wild Futures' holistic ethos is illustrated by its commitment to maintaining wildlife habitats on the Sanctuary site whilst applying sustainable environmental policies from energy use, purchase power to recycling.

Providing support to overseas projects in habitat countries with practical assistance, skills sharing, staff secondment, funding and advice are all part of the vital work of the charity in its aim to protect primates and habitats worldwide.

Covid-19 is causing devastation all across the world and like many others we are struggling as a result of this pandemic. We are facing one of our toughest years to date.

The Sanctuary is home to 40 monkeys rescued from situations of abuse and neglect from the UK primate pet trade. As fellow primates they may be very susceptible to Covid-19; many have heart disease and diabetes as a result of their lives as pets, raising the risks further. Wild Futures is taking every precaution to protect the monkeys, splitting the team on and off site and isolating the Sanctuary. Our main priority is to make sure the monkeys have the food and the medicines they need along with continued care.

However, overnight the charity lost its main sources of income from visitors, education, volunteer and training programmes. This has huge financial ramifications. We are facing troubling times.

We are appealing for emergency help to get us through this uncertain time.

Despite the challenges, we will continue caring for the rescued monkeys in our care and continue to promote primate welfare and conservation worldwide.

Please donate today www.wildfutures.org/donate and follow us on Facebook for updates.

Wild Futures, The Monkey Sanctuary, Looe,
Cornwall, PL13 1NZ. Tel: +44 (0) 1503 262532

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If you are a charitable organisation working in science, medicine, technology, education or conservation, and would like to find out more about this project contact Chris Martin on chris.martin@newscientist.com

Views

Letters
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Culture
Theo James tries to resurrect his wife as a machine in *Archive* **p24**

Culture
The *Snowpiercer* TV series is fun – just don't think too hard about the premise **p25**

Aperture
The weird moulds that feed on bacteria on forest floors **p28**

Columnist

Cleaning the air

How many plants do you need to purify the air in a small flat? A surprising amount, it turns out, finds **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, he shares his tiny London flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

AS YOU may know from my bio, I cohabit my small flat in London with more than 500 plants. I am therefore fascinated by the promise of a plethora of health benefits from gardening in the great indoors. With the current flowering of interest in the hobby, the internet is awash with handy advice for the "10 best air-purifying plants for the home" and species marketed as "Air so pure".

Being a stats geek, I wanted to calculate exactly how much the concentration of plants in my apartment could clean the air. This turned out to be a rather deep rabbit hole...

The seminal work on this subject came from NASA in 1989, after it investigated using plants as filters in space stations. In the study, researchers placed individual plants in tiny chambers filled with air contaminated with volatile organic compounds (VOCs). This group of chemicals includes known carcinogens like the benzene in cigarette smoke and the formaldehyde in paints, and it has been consistently linked to poor health outcomes.

NASA found that there was a significant improvement in the air quality in the chambers over a 24-hour period. Many headlines about how houseplants clean the air, including claims of a 90 per cent reduction in indoor air pollutants, have come from citing this three-decade-old paper.

While the study was well designed, there are a few caveats. Firstly, the "90 per cent" claim isn't for all plants, or even all pollutants, but a single stat for the ability of ivy to remove benzene from the air. Results for other plants and contaminants aren't as impressive, coming in at less than 10 per cent in some cases. So the way this study has been reported – including by me, I regret to say – exaggerates the actual ability of plants to clean the air.

Secondly, this experiment only looked at three VOCs. There are hundreds of other VOCs, as well as other ways to measure pollution, such as carbon dioxide and dust levels. So using this study as a definitive measure of overall "purity" in the indoor atmosphere is very tricky indeed.

> **"I like a challenge, but increasing my plant collection tenfold would mean entirely dispensing with furniture"**

However, perhaps the most important proviso is that the experiment was done in tiny, sealed chambers. So while it did a great job of demonstrating that plants can filter air, it didn't provide hard evidence that they can filter enough of it in a room setting to keep up with the level at which these pollutants are generated.

Fortunately, since NASA's study, dozens of others have investigated these issues. A review of these studies found that you would need between 10 and 1000 plants per square metre of a building's floor space to remove VOCs at the same rate as happens when air from indoors moves outside anyway.

So in my 50-square-metre flat, I would need around 5000 plants for them to be as good as simply opening a window. I like a challenge, but increasing my existing collection tenfold would mean entirely dispensing with furniture. But what about other measures of air quality? In lockdown, I have been stuck indoors, breathing out about 30 grams of CO_2 per hour. Research published by the University of Birmingham, UK, and the Royal Horticultural Society found that you would need 15 ivy or peace lily plants to reduce just 10 per cent of one person's contribution.

While fitting 150 such plants in my flat is theoretically possible, given some sort of living wall set-up, it should be pointed out that these two species were the best-performing plants in the study. With bromeliads, for instance, you would need more than 1000 specimens to do the same job.

I should have twigged this, really, as even mature tropical trees are estimated to absorb only 22 kilograms of carbon dioxide per year. I would therefore need more than 11 rainforest giants in my flat just to tackle the pollutants I breathe out. That's a lot of plants, even for me. ▮

James's week

What I'm reading

Tutorials about fuku bonsai, a school of bonsai first developed in Hawaii in the mid 20th century by Japanese immigrants.

What I'm watching

I am the world's biggest fan of David Olusoga. His recent BBC documentary on black British history is fascinating.

What I'm working on

Geeking out on an episode of Gardeners' Question Time.

This column appears monthly. Up next week: Chanda Prescod-Weinstein

Editor's pick

On the hunt for the cause of post-Lyme syndrome

6 June, p 40

From Stephanie Woodcock, Truro, Cornwall, UK

Chelsea Whyte examines several hypotheses about post-treatment Lyme disease syndrome. Rather than simply being a chronic effect of Lyme disease, which results from infection by the spirochaete bacterium *Borrelia burgdorfer*, Marcelo Campos says the syndrome may be an entirely different condition caused by another bacterium also spread by ticks.

He also notes: "If you don't know what you are looking for, then how do you test for it?" This might be especially relevant if any other organism responsible were also a spirochaete, as these are often hard to culture and study.

The idea that any such organism could be spread by tick bites would explain the association with Lyme disease. As Campos further notes, co-infections can be common in Lyme disease.

If the putative organism were a spirochaete, it doesn't seem unreasonable to wonder whether there would be a good chance that the range of symptoms would also be similar to Lyme disease. This would make the diagnostic picture very hard to disentangle.

Since treatment would probably involve the early administration of antibiotics, accurate diagnosis would seem urgent so that people can get timely medication.

Other impacts possible for those who had covid-19

27 June, p 34

From Robert Saunders, Balcombe, West Sussex, UK

In your article "The enduring grip of covid-19", Paul Garner says his symptoms "are the same as chronic fatigue syndrome, with one difference – CFS is defined as not having a cause".

That isn't accurate. Because there are currently no diagnostic tests for CFS, also known as myalgic encephalomyelitis (ME), other possible causes of symptoms must be excluded before a diagnosis can be made.

However, it is well established that this illness can be triggered by infections such as the Epstein-Barr virus, and it is possible that covid-19 could lead to ME/CFS in certain cases.

Surely recycled indoor air is a coronavirus risk factor

Letters, 2 May

From Lynn Brookes, Preston, Lancashire, UK

Alan Harding wonders if air conditioning is a risk in spreading the coronavirus. I would say there is little doubt it can spread disease when you consider the issues of recycled air in aircraft and sick building syndrome in high-rise office blocks.

Oxygen isn't always a good thing for life

20 June, p 40

From Craig Hutton, Southampton, UK

Your excellent interview in which Kevin Hand discusses the possible exploration of our solar system's moons offers the prospect of finding not just microbial life, but even multicellular life on Europa, which orbits Jupiter.

This suggestion is based on oxygen being delivered to the ocean below as a result of chemical changes caused by Europa's frozen surface being bombarded by charged particles. While the rise of oxygen on Earth is considered to have fuelled the emergence of multicellular organisms, the vast majority of unicellular life evolved in an anaerobic environment over billions of years prior to the rise in oxygen in our air and oceans.

Oxygen would have been toxic to early life on Earth. So if it were present early in Europa's history, as seems likely, might that not be a barrier to the evolution of life?

Reasons to doubt a fusion-powered world

13 June, p 30

From Christopher Jessop, Marloes, Pembrokeshire, UK

You consider developments that might help nuclear fusion become a reality. But even if it does, do we want society to be fusion-powered?

Like fission, fusion will always profligately consume engineering skill and capital investment, and it would mean putting all our eggs in one basket. If a fusion plant design has an unexpected problem, what would we do? Shut the grid or keep going with fingers crossed?

Maybe wind, solar and tidal energy will provide some relief. But, according to the article, "they are limited and unpredictable". Never mind commercial fusion being 30 years away – that view of renewables is 30 years out of date.

Wind and solar work at all scales, on and off-grid. They offer autonomy and, through social ownership, everyone can share the benefits. They are already the cheapest electricity sources, with regular improvements in efficiency and economies of scale.

What's more, wind and solar are compatible with energy storage systems of all types and could be used to make hydrogen fuel.

From Alexander Cannara, Menlo Park, California, US

With two advanced degrees in plasma physics, I wouldn't advise anyone to follow Abigail Beall's optimism on when fusion power will be a reality, with or without the help of artificial intelligence.

The Stanford plasma physics group I was involved with may have a 100th anniversary in 2061. Bets on its food and drinks being prepared via fusion electricity?

From Simon Newton (of Moltex Energy), Rous Lench, Worcestershire, UK

Your article writes off nuclear fission in less than a sentence: "Nuclear fission comes with the dangers of reactor meltdowns and radioactive waste."

In fact, there is a well-known form of fission, using molten salt reactors, which has neither of these problems. The nuclear reaction in such reactors slows as temperature increases, so no meltdowns. At least one molten salt reactor actually uses existing nuclear waste as its fuel.

These reactors are low cost to build and operate. We have a clean and safe solution to climate change right in front of us, yet we repeatedly and wilfully ignore it in favour of a more distant hope. Our children aren't going to thank us.

What came first, laughter or a happy mind?

27 June, p 28

From James Stanton, Derby, UK

Your article on the wider body's role in consciousness was fascinating, but this idea was anticipated long ago.

The US philosopher and psychologist William James was a proponent of the idea of embodied cognition towards the end of the 19th century. "We don't laugh because we're happy, we're happy because we laugh," he said, encapsulating his idea that mental states follow bodily sensations rather than the other way round, as seems the more logical order. ▮

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 25 Bedford Street, London WC2E 9ES will be delayed

For the record

▮ Aya Osman was born in Saudi Arabia and, on her first day of orientation for a postdoctoral degree in the US, was one of a handful of black doctors (27 June, p 14).

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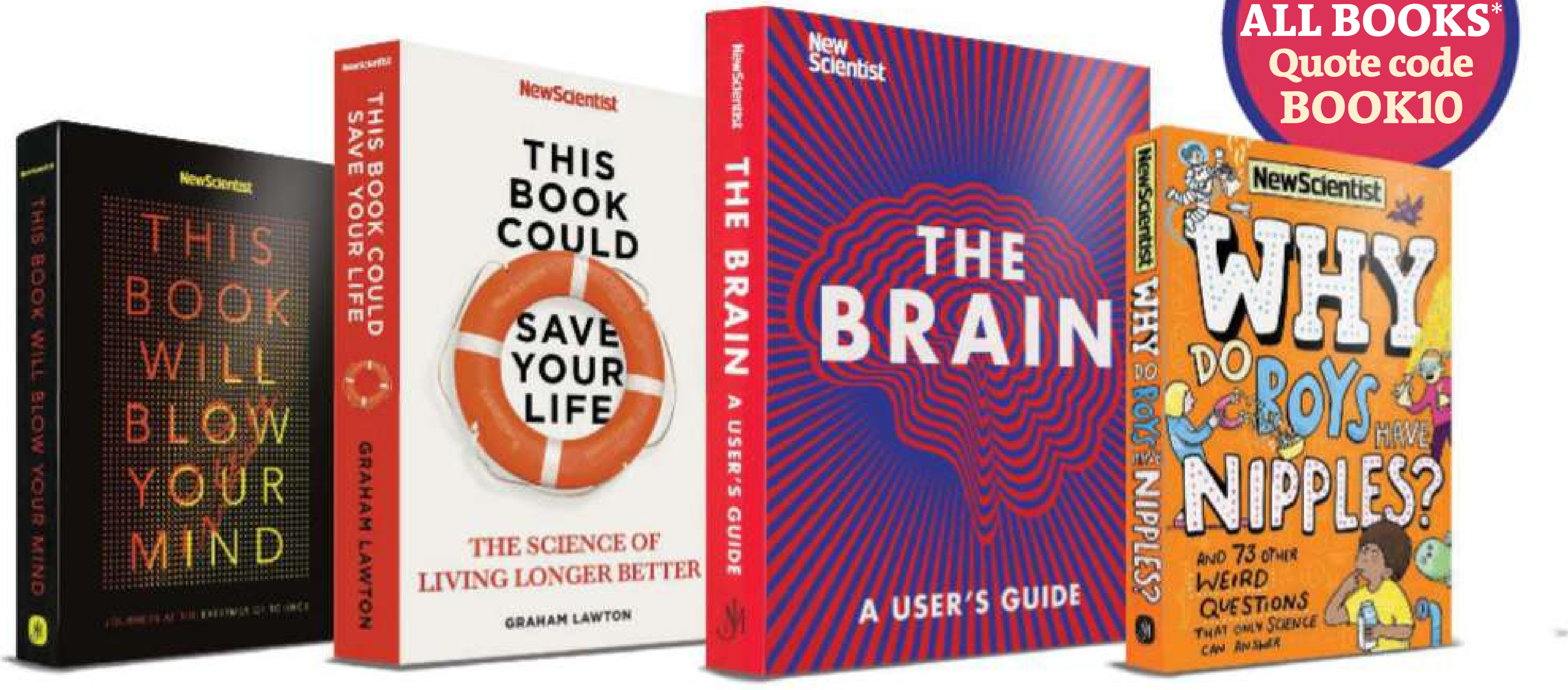

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Robot resurrections

In *Archive*, George Almore tries to put his late wife's memories into a machine. The project is far from a roaring success, finds **Jon O'Brien**

Film

Archive

Gavin Rothery

Available on demand from 10 July

"HE WHO remains passive when overwhelmed with grief loses his best chance of recovering elasticity of mind," Charles Darwin once wrote.

Passiveness certainly isn't a trait that can be attributed to *Archive*'s leading man George Almore (Theo James). He is a bereaved researcher secretly attempting to resurrect his wife, played by Stacy Martin, using analogue memories and robotics.

We meet George in 2038, two years and two prototypes into his mission. He has produced J1, a boxy, WALL-E-esque figure that is slightly rigid and watches vintage cartoons, and V2, its more advanced "sister" with a jealous streak.

Holed up in an isolated facility deep in the heart of Japan's snow-capped Yamanashi prefecture, George must care for these specimens of "deep-tiered machine learning and artificial intelligence" while keeping his project a secret.

Having lived through the road accident that killed his beloved, Almore cuts an enigmatic yet often sympathetic figure. He has genuine compassion for the robots, all too aware they are essentially failed experiments. And there is a palpable survivor's guilt driving his mission.

Though the film is very much about Almore, there are other good characters too. Take the hard-nosed, hologrammed vice president (Rhona Mitra), for example, who is threatening to withdraw funding from the project providing Almore's cover. There's also Toby Jones's inquisitive company representative, who suspects that the 200 hours of posthumous conversation data from Almore's wife is being misused. Oh, and let's not forget the gun-toting risk-assessor, played by Peter Ferdinando.

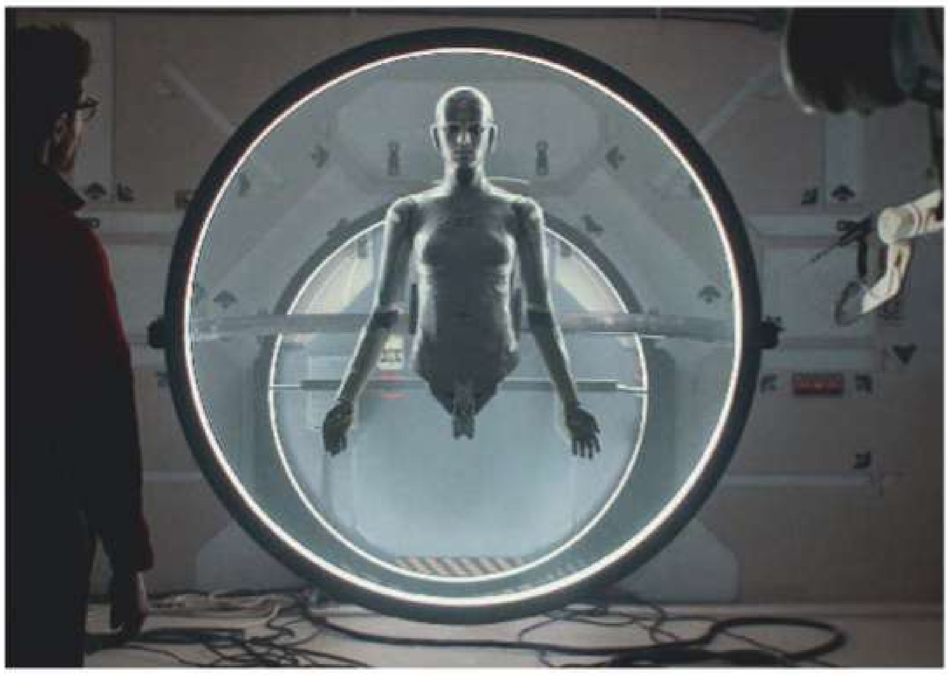
The film will inevitably be compared with an episode of *Black Mirror* called "Be Right Back", in which a widow revives her partner, who died in a car crash, using a mail-ordered digital consciousness.

"Almore has genuine compassion for the robots, all too aware they are essentially failed experiments"

Archive, however, focuses just as much on the mechanics behind the concept as its implications. Version 3.0 of Almore's robot wife turns out to be difficult for him to control. Her construction from confused, disembodied head and torso to fully realised ghost-white being is also remarkable, and sometimes very disturbing to observe.

This is a feature-length debut for writer and director Gavin Rothery. His only previous sci-fi work was a 2014 short called *The Last Man*, in which a soldier is awoken into a war-ravaged world. Rothery also supervised the visual effects on *Moon*, including parts of the eerie mining facility that the film is set in.

While it doesn't quite hit all of the heights that it could, *Archive* is an entertaining watch. Its clever ruminations on free will, grief and immortality provide an immersive and visceral experience – one that, like its protagonist, is anything but passive.



VERTICAL ENTERTAINMENT

J3 is George Almore's third robotic attempt to resurrect his late wife

---

Is there another planet in the universe just like ours?

Podcast

Exoplanets: The search for another Earth

Audible

THE hunt to find exoplanets like our own has only just begun. In 1992, the first planets outside our solar system were discovered via a pulsar 2300 light years away that signalled at slightly odd intervals, indicating there were two worlds orbiting it. Now, we know there are potentially millions of them out there and more are found every day, says Danielle George, the host of *Exoplanets*, a six-part series on Audible.

George is an experienced guide to the galaxy: she has worked with Stephen Hawking on the search for far-off worlds, as well as NASA and the European Space Agency. With other researchers as guests, she tackles questions about the size of the universe and what kind of life may live within it.

Though it lacks drama at times, the series is an interesting look at the current state of exoplanet science. George, an optimist, believes there is another Earth-like planet out there somewhere. Any plans for humans to visit such a place should be shelved, however, as exoplanets are all very far away.

The thornier question, then, is: are we alone or could there be intelligent life on an exoplanet somewhere? The series comes to an answer – sort of. If there were other advanced societies out there, surely they would have attempted to detect us in search of another home? Perhaps they don't need to, having taken better care of their home planet: a message that George says we need to take to heart.

Chris Stokel-Walker

Dystopia express

A train called *Snowpiercer* loops the planet after a global disaster, as an onboard mystery keeps the plot rolling, says **Emily Wilson**

TV

Snowpiercer

Streaming on Netflix

This review is designed to be as spoiler-free as possible. It was written based on the first five episodes

NETFLIX

Jennifer Connolly, Mike O'Malley and Daveed Diggs in *Snowpiercer* (left to right)

SNOWPIERCER is set in a nearish future in which some last fragments of humanity live on a train powered by an "eternal engine". This 1001-carriage-long ark endlessly circles a frozen Earth made uninhabitable by bungling geoengineers who had been trying to fix climate change.

If you can accept the central premise for what it is, asking no awkward science questions about eternal engines or how a rail track can circumnavigate the globe, then there is plenty to enjoy on board *Snowpiercer*.

The plot, based on a film by Bong Joon-ho (now of *Parasite* fame) and before that a French graphic novel, imagines the train as a "fortress to class".

Up front, a few privileged families live a life of luxury, the decor a cross between a Wes Anderson movie and an Agatha Christie novel.

Next, you get second class (not quite as nice, more economy lodge) and third class (a bit *Blade Runner*, loud music, steam punk vibe).

Finally, right at the back, you get the filthy wagons occupied by "tailees" who got on the train without a ticket and have subsequently been treated very poorly indeed.

Our two lead characters hail from opposite ends of the train. From the front, we get the leader of train hospitality, Melanie Cavill, played by Jennifer Connolly. Her job is to ensure perfect order on the train or, as she puts it, she "wears many hats". Connolly, very elegant in her gorgeously cut turquoise uniform, is a mysterious and queenly, yet very human, presence.

Then, from the back of the train, we get a former homicide detective called Andre Layton, played by Daveed Diggs. He has spent the seven years since the train set off living in conditions of horrific squalor, scrabbling to make ends meet, endlessly working towards the revolution that the tailees long for.

> **"Right at the back, you get the filthy wagons occupied by 'tailees' who got on the train without a ticket"**

The two leads meet when Layton – as the only murder-solving police officer left on the planet – is scrubbed clean and then dragged forwards from the tail to solve a killing "up train".

The police procedural is a bit of a clunky addition to a show about a dystopian future on a train cutting through avalanches, but the advantage of it, of course, is that we get to explore the train properly as our cop pokes around, looking for the killer.

We get to see carriages devoted to agriculture and even a lovely aquarium, as well as the various living quarters of our new *Snowpiercer* friends and a secondary rail system sitting under the carriages that takes workers hither and thither.

As well as piecing together the main murder story, we get to piece together clues about a different background puzzle: the underlying mystery of Mr Wilford. He is said to be the owner and inventor of the train, and to be on board, although the ticket holders don't see him.

I can't quite work out yet how this story can keep going beyond its initial 10 episodes, given how tiny this closed world is – will they meet other people, get off the train?

Either way, season 2 has already been commissioned, so it looks like this eternal engine will keep rolling for some time to come, if not for eternity. ■

Don't miss

Science Fictions

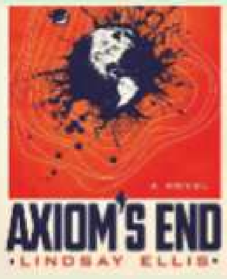
Stuart Ritchie

Read

Science Fictions: Exposing fraud, bias, negligence and hype in science is psychologist Stuart Ritchie's manifesto for an overhaul of the scientific process. He says disturbing flaws are endemic in many fields, but there are solutions.

Watch

The Old Guard sees Charlize Theron lead a cast of unkillable warriors on a winding route between CCTV cameras and other people's cellphones in a desperate attempt to hide from the modern world. It is available on Netflix from 10 July.


A NOVEL

AXIOM'S END

LINDSAY ELLIS

Read

Axiom's End features YouTuber Lindsay Ellis's entertaining deconstructions of pop culture in an alternate history of 2007, the year we first encountered an alien species. Who will translate for the monsters?

THE OLD GUARD/NETFLIX

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Rosalind Franklin

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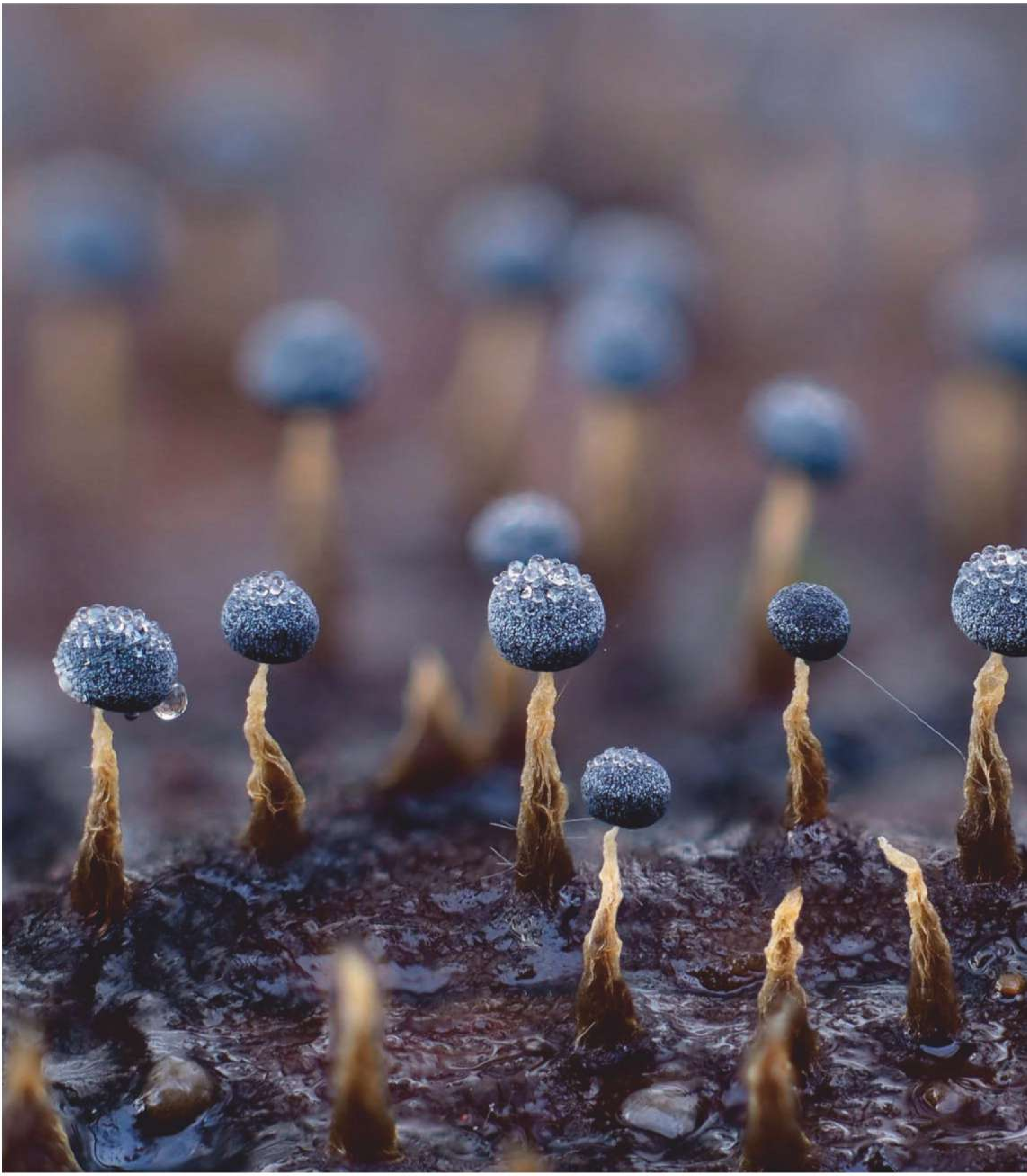

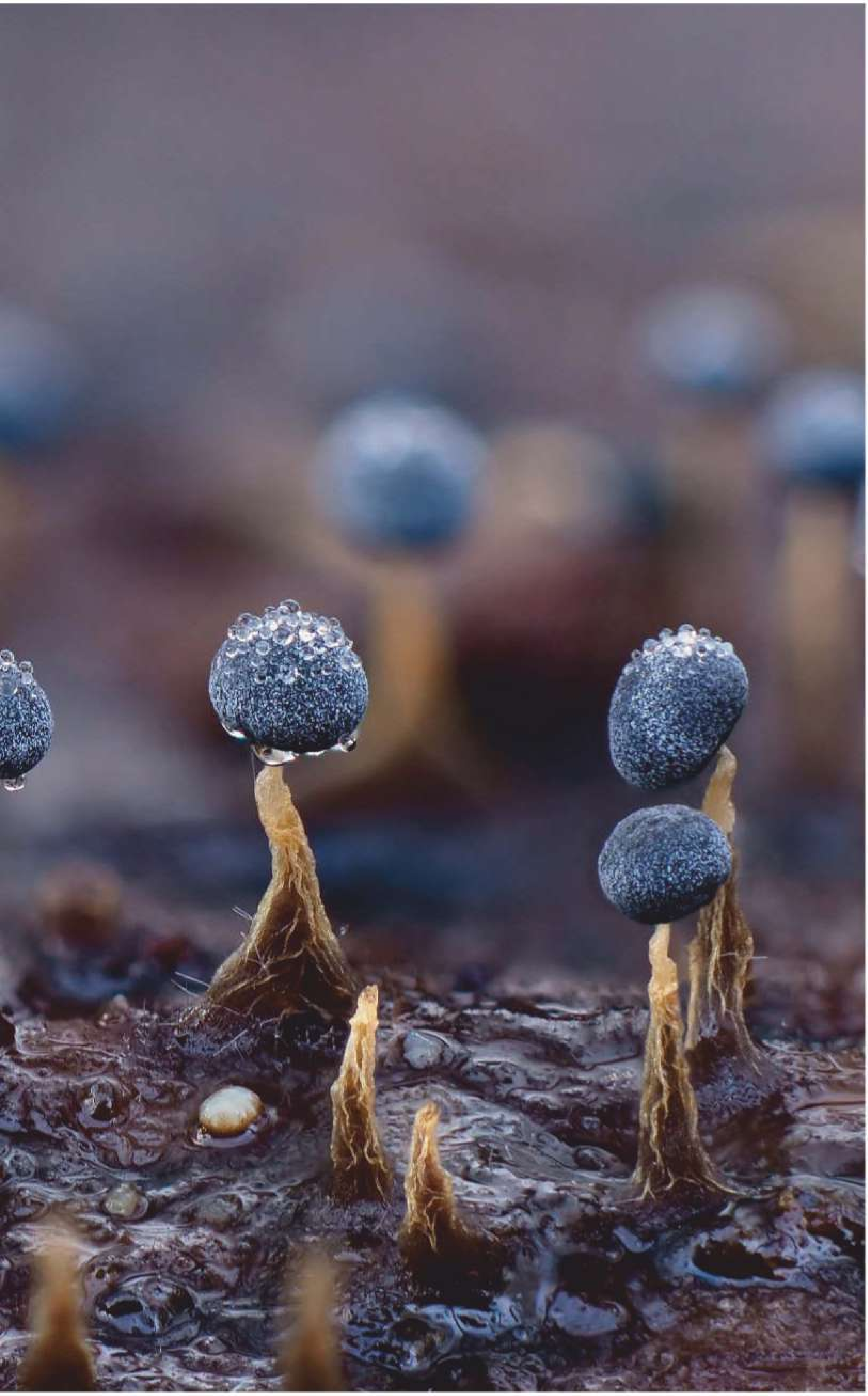

Slime balls

Photographer **Andy Sands**
Agency **naturepl.com**

THOUGH they may resemble something from another planet, these strange, mushroom-like structures are in fact the reproductive phase of *Physarum album*, a slime mould species that feeds on bacteria on forest floors.

Perched on top of each "stem" is the slime mould's fruiting body, containing thousands of spores that burst and release their contents when the mould is ready to reproduce. Intricate though these structures are, most are only a few millimetres high. This makes them "painstakingly difficult to find", says photographer Andy Sands from Hertfordshire in the UK, who took this shot.

Slime moulds start out as single cells and can remain in this form all their lives if enough food is available. However, when supplies are scarce, hundreds of thousands of individuals can merge into a single, moving mass in the search for food.

Fossils indicate that such organisms have existed almost unchanged for some 100 million years, possibly because slime moulds possess a remarkable memory and problem-solving skills. They are so good at working out the most efficient routes to food that researchers have looked to them when designing transport networks. ▮

Gege Li

BROOKE SHADEN

Rethinking gravity

Theoretical physicist **Claudia de Rham** has shown that gravity itself could have a mass – giving us a whole new picture of this fundamental force

SOME 384,400 kilometres from Earth, the moon glides silently through space. Actually, we can do better than that: we know exactly where the moon is now, and what path it will take around us, to within a millimetre. To be any more accurate, we would have to consider details of Earth's mass distribution as subtle as the mass of leaves growing in the spring in one hemisphere as they wither in the other.

The laws of gravity govern the moon's trajectory, and the precision with which we understand them is thanks to the equations of general relativity, finalised by Albert Einstein just over a century ago. Those same equations apply across the solar system and beyond. Our understanding of gravity is one of the most impressive achievements of our species.

But there is a problem. General relativity doesn't align with quantum theory, our most successful attempt at understanding reality so far. And the universe is expanding at an accelerating pace that doesn't tally with gravity's attractive nature. Our existing picture may allow us to predict the motion of the moon, but when it comes to explaining the wider cosmos, we're missing something.

My attempts to find out what have led me to ask whether gravity itself has a mass. Physicists have argued about this for decades. Now my colleagues and I have stumbled on an intriguing answer that may lead us to a clearer picture of gravity. If we are right, then this most enigmatic of forces not only does have a mass, but the evidence that proves it is painted across the cosmos.

One of the most remarkable things about gravity is that, in contrast to other forces like electromagnetism, its effects are universal. It was Galileo who first grasped this in about 1590. Whether he really dropped objects with different masses from the Leaning Tower of Pisa or not, he had the beautiful insight that Earth's gravity is felt the same way by everyone and everything. Indeed, if it weren't for air resistance, a hammer and a feather dropped simultaneously would hit the ground at the same time. We have tried this experiment on the moon where there is no air resistance and shown that Galileo was right.

A century later, this ubiquity was at the centre of Isaac Newton's formulation of the laws of universal gravitation. It is essentially these laws that enable us to predict the motion of the moon and the planets with such incredible accuracy. Newton's laws get the moon's orbit right to within 10 centimetres, and corrections introduced by Einstein make it better still.

But there is one conceptual aspect behind Newton's laws that is a source of deep concern. It is the instantaneous way in › which Newton assumed that gravity acts. To see why it is so troubling, imagine that the sun disappears. According to Newton, we would feel the lack of the sun's gravitational tug instantly, so that even as Earth careered off its usual orbit, we would see our now-vanished star shining benignly above us for 8 minutes and 20 seconds or so. The result of this thought experiment offends our understanding that nothing can travel faster than light, not even gravity.

This maxim originated with Einstein. He showed that Newton's laws explain gravity only when the motion of objects is slow compared with that of light. He then formulated general relativity as a more complete picture of gravity. It remains our best effort to this day.

So how does gravity work? While Newton's theory barely engaged with this question, Einstein gave us an answer that transformed how we think about reality. General relativity paints space and time as a unified entity called space-time that flexes and adapts to everything within it. The reason that objects move as they do in response to gravity can be explained by the bulges in this flexible canvas of reality.

If that is tricky to visualise, here is an analogy. If you have ever flown long-distance, you might have looked at the maps of your flight path that are sometimes displayed on the entertainment screens. It always looks like an arc on the map, not a straight line, say from east to west if you are crossing from Europe to the US. But that is an illusion. The pilot will fly as straight as an arrow; it is only because Earth's surface itself is curved that the flight path looks that way too when displayed in two dimensions. General relativity explains the dance of the planets in a similar way. They seem to follow elliptical orbits, but are actually moving efficiently in straight lines through curved space-time.

This strikingly strange theory was the first of two 20th century revolutions in physics. The second, quantum theory, was, if anything, even more profound. Quantum theory deals with the smallest aspects of nature and shows us that this world is nothing like the one in

Boson bonanza

All the fundamental forces are thought to be carried by particles called bosons. The theoretical graviton is a shadowy boson we know less well than its siblings

BOSON	STATUS	FORCE	MASS
PHOTON	**Detected.** Special cameras are capable of picking up single photons	**Electromagnetism** acts only on charged particles. Vibrations in this force's quantum field create electromagnetic waves, including visible light	Below 10^{-54} kg; believed to be massless
W and Z	**Detected.** These particles were observed at CERN in 1983	The **weak nuclear force** acts on subatomic particles and is responsible for radioactivity	W: 1.4×10^{-25} kg Z: 1.6×10^{-25} kg
GLUON	**Inferred.** We can't observe gluons in isolation, but we know they exist from patterns observed in decays of other particles in accelerators	The **strong nuclear force** holds together quarks, the building blocks of protons and neutrons inside atoms	Believed to be massless
GRAVITONS	**Undetected.** We discovered gravitational waves in 2015 and believe these should manifest as gravitons in some circumstances. But we have yet to see them directly	Like electromagnetism, **gravity** acts over huge ranges. But it is felt in the same universal way by all objects, regardless of their mass or charge	Below 10^{-58} kg

Everything feels gravity in the same way. Size, shape and orientation make no difference

JASON RIBES

which we spend our days. Down there, it doesn't make sense to speak of particles occupying particular places, they exist only as a nebulous cloud of probabilities. It sounds odd, but we know this idea to be as right as anything in science can be.

For that reason, it is worth taking seriously what quantum theory says about forces. At its heart are quantum fields that can form waves and propagate through space. It turns out that it is equally valid to think of these waves as particles. This applies to light itself. When physicists talk about light, they sometimes talk about waves in the electromagnetic field and at other times they talk about photons, the particle, or boson, that carries the electromagnetic force.

> **"These 'ghost' particles would wreak havoc, quickly erasing all order in the universe"**

Quantum theory in fact says that each fundamental force has its quantum field and one or more bosons (see "Boson bonanza", left). It also says that the mass of a boson is inversely proportional to the range of the force. This is why light, carried by photons that we believe to be massless, has an infinite range. That's why we can see stars on the other side of the universe. If a force has heftier bosons, its reach is more limited.

There isn't yet a complete quantum theory of gravity, but we do have strong evidence that this force must ultimately fit into the quantum mould. That means space-time is a quantum field and that waves in it can also be thought of as a boson. We call this particle the graviton.

We don't know for sure that gravitons exist, but all the signs point that way. Take the discovery of gravitational waves by the Laser Interferometer Gravitational-Wave Observatory (LIGO) collaboration in 2015. This showed that the gravitational field can vibrate just like the electromagnetic field. As yet, these waves show no trace of quantum behaviour, so they aren't direct evidence for gravitons. But they are a highly suggestive hint that they are out there.

We have some knowledge about what gravitons ought to be like. Gravity exerts its influence across cosmic scales just like light, so the graviton must be either massless or very light. But which is it? This seemingly innocent question matters because the answer will reveal how gravity behaves over the largest of distances and how fast gravitational waves move. If gravitons have no mass, then we know from the mathematics that they must travel at the speed of light. However, if they have mass, they can travel at different speeds.

Physicists have jousted over this question for decades, but the argument was silenced when we realised that there was a problem with the very idea of a massive graviton. It turns out that if gravitons have mass, they instantly acquire the ability to come in different varieties, each with different quantum properties. As physicists have tried to describe these various types of gravitons, they have found they couldn't avoid one of them coming out as a "ghost": a particle with negative energy.

These ghosts would wreak havoc. There would be nothing to stop them interacting with regular particles in a chain reaction that would quickly erase all order in the universe. The fact that this hasn't happened means ghosts can't exist, and so gravitons can't have mass.

Extra dimensions

That, at least, has long been the argument. Contradicting it was far from my intention when I teamed up with my husband Andrew Tolley, who works with me at Imperial College London, and Gregory Gabadadze at New York University. We were interested in an entirely different problem. The expansion of the universe is accelerating much slower than we anticipate when we combine predictions from quantum field theory with general relativity. Our aim was to explore whether the laws could differ at cosmological scales and so level the balance. There were two ways to do this: invoking extra dimensions or allowing the graviton to have mass. We thought that the extra dimensions route was distinctly more plausible.

We discovered something remarkable. When we played around with models of general relativity that included extra › dimensions, it seemed possible to have massive gravitons without any ghosts. This wasn't a model that could describe the real universe, but it showed that massive gravity wasn't quite as impossible as we had always thought. And switching back to thinking about four-dimensional space, we found a way to describe massive gravitons in such a way that they didn't inevitably produce those troublesome ghosts. It is the first consistent, rigorous theory of massive gravity.

If we are right, and the graviton has mass, it would change the way we think gravity operates. The effect would touch all sorts of processes, from the early evolution of the universe to the motion of the planets and the fate of the cosmos. Even the path of the moon would be affected: there would be a tiny extra attraction between it and Earth, changing the lunar orbit so that its position would be different by about a nanometre each month.

More profound would be the effect on the speed of gravitational waves. Take a collision between two black holes, one so epic that it creates detectable waves in space-time – the sort of thing LIGO first detected. If gravitons have mass, it means these waves don't have to travel at the speed of light in a vacuum. Instead, you might have a situation similar to what happens when light is refracted by a raindrop, where the different frequencies or colours of light change speed by different amounts and so spread into a rainbow. "Gravitational rainbows" wouldn't be coloured, but if gravitons do have mass, they ought to be spreading through the universe all the time. None of the gravitational waves detected with the LIGO detectors have shown any signs of being part of a rainbow, but it isn't out of the question that we might see one in future detectors.

> **"Gravitational rainbows ought to be spreading through the universe all the time"**

ILKA & FRANZ/GETTY IMAGES

If gravitons do have a mass, however small, it would force us to rethink how gravity works

THOMAS ANGUS

PROFILE
Claudia de Rham is a professor of theoretical physics at Imperial College London. She received the 2020 UK Blavatnik Award for achievement as a young scientist in recognition of her work on massive gravity

I like to think of gravity as the force that connects us all. Every time we probe it more deeply, a new and unexpected layer of rich and fundamental structure is unveiled. Newton's laws are beautiful in their simplicity. Einstein's theory rewrote our assumptions about space and time. Now, the search for quantum gravity is leading us towards a new understanding of fundamental particles. In parallel, it is possible that we are getting a first glimpse of what the graviton is like. These advances don't invalidate the older theories, of course – they provide a more fundamental description of nature.

Whether or not we are right about massive gravitons, physics is certainly entering a new era in which we understand gravity better than ever. Just compare what we now know about the seemingly obscure graviton with our knowledge of the photons that constantly stream into our eyes. Measurements of gravitational waves have already provided us with a more accurate limit on the mass of the graviton than that of the photon. Despite the graviton being so mysterious, this is one way in which we already know it better than light itself. ▮

Welcome to our Signal Boost project. In these difficult times, we are offering charitable organisations the chance to take out a page in *New Scientist*, free of charge, so that they can get their message out to a global audience. Today, a message from **Practical Action**

Practical ACTION

A world that works better for everyone is anything but normal

The worldwide coronavirus crisis has emphatically proven that the systems that underpin human society are at best fragile, or at worst fundamentally unfit for purpose.

Around the world, food supply chains have broken down, health services have been overwhelmed and millions of jobs have been lost. Increasingly, people are questioning whether a return to 'normal' will ever be possible, but maybe we should be asking: "can we do better than normal?"

The answer is 'yes', according to international development group Practical Action. Founded by radical economist and philosopher E.F. 'Fritz' Schumacher, author of 'Small is Beautiful', the group has challenged accepted thinking for more than 50 years. They have a remarkable track record of helping people reimagine normal and reshape the systems their lives are built on.

In drought stricken Sudan, it's not industrial agriculture or big business that's helping farmers secure the food supply chain and re-green the desert. It's Practical Action's clever combination of business and farming knowledge transfer, solar-powered irrigation, better seeds and a whole lot of shared effort. Farmers have been able to turn the tables on climate change and turn barren land into lush fields and forests – and quadruple their incomes.

In Bangladesh, it's not an increase in public spending that's cleaning up city slums for people. It's Practical Action, bringing low-income communities, local government, businesses and self-employed waste workers together to create the right plan. This approach has been adopted as national policy in Bangladesh and millions more will now have access to safe water and sanitation systems.

And in Zimbabwe, it's not an extension of the national grid that's transforming lives through the power of clean electricity. It's Practical Action's work to establish solar "mini-grids" for remote communities. These are now powering up homes, schools, health clinics, workplaces and crop irrigation systems. Almost every aspect of life has improved - and as people become more productive, they earn more and can pay for the electricity they use.

As we think about the sort of post-crisis world we want to shape, let's aim for anything but normal. Practical Action's work clearly shows us that with a little ingenuity and a lot of shared effort, we can build a world that works better for everyone. Let's do it.

To explore or donate to Practical Action's work, visit practicalaction.org/newscientist

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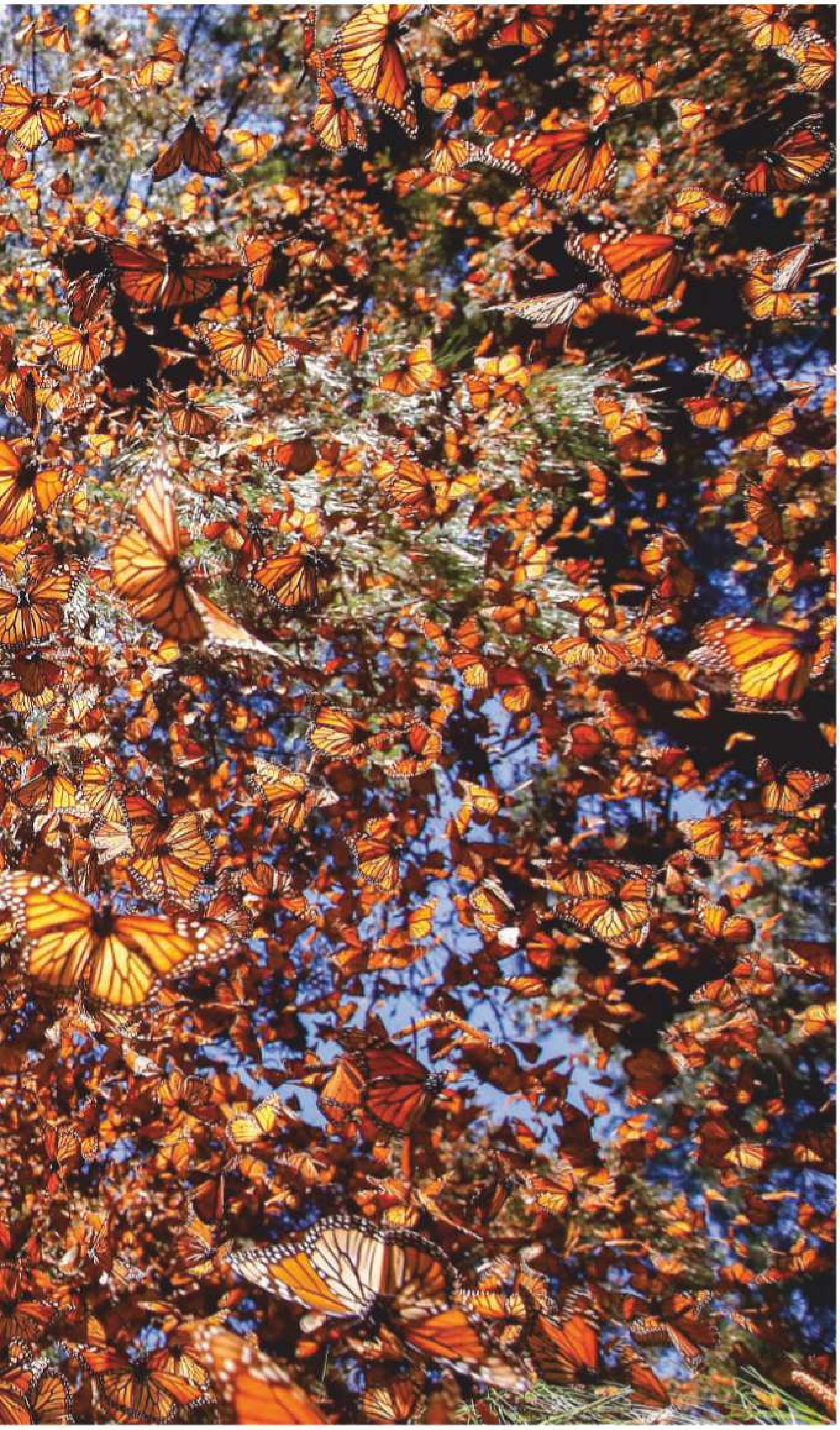
If you are a charitable organisation working in science, medicine, technology, education or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

Soft-winged sentinels

If you want to see how wildlife will cope with climate change, take a look at butterflies, says **Madeleine Finlay**



SYLVAIN CORDIER/NATUREPL.COM

CHRISTIAN MUSAT/ALAMY

THE long-tailed blue butterfly, named for the stringy "tails" on its wings and its iridescent azure colour, is common across Africa and southern Europe. It has rarely ventured as far north as the UK. In fact, for most of the time since one was first recorded on the south coast of England in 1859, only a few dozen more had been spotted there. But over the past decade or so, the long-tailed blue (pictured above) has been arriving in the country during the late summer in greater and greater numbers. Last year, eagle-eyed gardeners saw at least 50 adults and hundreds of eggs.

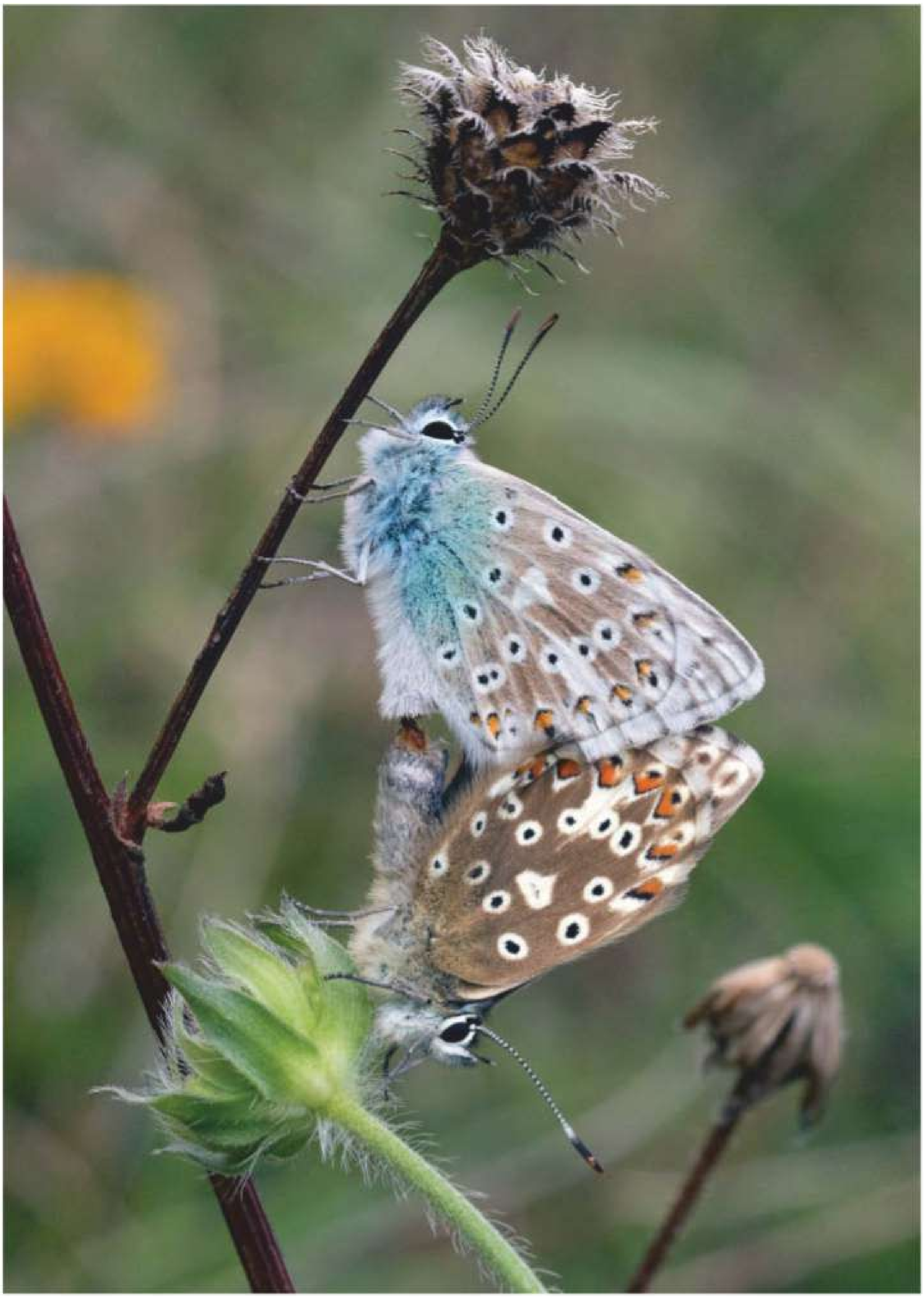
The sight of such exotic visitors is a thrill for butterfly enthusiasts. For conservationists, it is something else entirely: a worrying confirmation that butterflies are already feeling the effects of human-induced global warming. "This isn't something that's 50 years ahead. This is happening right now," says Dan Hoare, an ecologist and director at UK-based charity Butterfly Conservation. Although the long-tailed blue is taking advantage of rising temperatures by expanding its range, most wildlife won't have it so good. "The long-tailed blue should make us think twice about how nature is going to be able to adapt," says Hoare.

As it happens, watching butterflies is one of the best ways to answer that question because these fragile, transient creatures are bellwethers. When it comes to understanding how climate change is affecting wildlife › and ecosystems, their lifestyles and famous visibility make them uniquely revealing. So, as temperatures rise, what is becoming of butterflies? And what do their various fates tell us about how climate change will affect biodiversity in general?

Butterflies aren't facing global warming on a firm footing. Around the world, populations are experiencing steep downturns. In the UK, as the long-tailed blues have moved in, there have also been serious long-term declines in the majority of butterfly species. It is a similar story wherever there are reliable figures. Butterfly numbers in the Netherlands have dropped by more than 80 per cent since 1890, for instance, while all 26 species listed as threatened or endangered in the US have dwindled to the point of extinction.

Much of that decline has been attributed to habitat loss and the use of pesticides. But now the effects of global warming are beginning to bite too. The role of human-induced climate change has, so far, been difficult to disentangle. The intricate and interwoven effects that global warming can trigger, from severe weather to shifts in the timing of plant life cycles, make it challenging to decipher the cause of any given species decline. Yet butterflies offer a unique chance to see through the fog.

As cold-blooded animals that depend on the climate to regulate their temperature, they are sensitive to warming. Their short but complex lifespans also mean that knock-on effects quickly become apparent, although that fleetingness should also give them the capacity to adapt faster than most. "Many species of butterfly have more than one generation a year and are thus subject to rapid selection pressure compared to longer-lived mammals or birds," says Hoare. "Their diversity, with varying lifestyles and ecological niches, offers lots of opportunities to respond to environmental change."



DAVID KJAER/NATUREPL.COM

"Emerging earlier can throw butterflies out of sync with their host plants"

MEDFORD TAYLOR/NATIONAL GEOGRAPHIC

ANDY SANDS/NATUREPL.COM

The black swallowtail (above) is moving north while the northern brown argus (near left) has changed its host plant. If the chalkhill blue (opposite page) is to survive, it might have to do both

The same could be said of nearly all insects. The problem is that there is precious little data on many of them. Butterflies, on the other hand, are well-documented, having long been a favourite of keen-eyed amateur biologists who collect information about their comings and goings.

As a good proxy for other insects, butterflies serve as an early indicator for the impact climate change will have more generally. By studying them, we get the first indication of how human-induced warming is playing out, telling us which species might have the capacity to adapt, what it takes to do so and the extent to which adaptation can keep pace with rising temperatures.

One of the most obvious responses to global warming is the drift of species away from the equator and towards the cooler climes of the poles. Long-tailed blues heading northwards are far from the only example. A recent study showed that the area in which Canadian and eastern tiger swallowtail butterflies meet and interbreed – a strip of land stretching from Minnesota to New England – has shifted 40 kilometres north since the 1980s. Other butterflies are moving upwards too, with higher elevations offering optimum temperatures as the climate warms.

Nowhere to go

Yet for those cold-adapted species of butterfly that had already made higher altitudes home, there is quite literally nowhere left to go. In some cases, they are being pushed to the brink of extinction. Take the mountain ringlet, an upland species found in the north of England and Scotland that is beautifully adapted for cold and damp conditions. It is a specialist butterfly, meaning it can only thrive in very specific circumstances. Previously, it could be found as low as 200 metres above sea level. "Now it's been pushed to 500, 600 metres and up," says Andrew Bladon at the University of Cambridge. "The highest mountains in the UK don't go much above 1000 metres. There's very little space left for that species. At some point, it will disappear because of climate change."

Indeed, specialists everywhere are particularly vulnerable to climate change. As average temperatures rise, many butterflies are emerging earlier in the year. This is fine for species with multiple breeding cycles per year and some level of flexibility in their preferred habitat. But it is bad news for single-generation butterflies that rely on a restricted number of plant species to feed their caterpillars, according to an analysis of 130 different species carried out last year by Callum Macgregor at the University of York, UK, and his colleagues. Emerging earlier tends to throw them out of synchrony with their host plants.

It is possible to find a new niche, as the northern brown argus demonstrates. In mainland Europe, this species feeds mostly on geraniums, but in the UK, the caterpillars prefer rock roses – or at least they did. ›

STEVE GETTLE/MINDEN PICTURES

Sulphur butterflies in the Rocky mountains have evolved lighter wings since the 1970s

“Just like shopping malls, ecosystems will looks increasingly homogenous”

“It was assumed that the British population was a subspecies that had specialised for some reason,” says Bladon. As the climate has warmed up, however, the caterpillars of the northern brown argus have switched to geraniums.

For Bladon, this suggests that the plant itself could be less important than the microclimate it generates – geraniums provide cooler spots than rock roses – and raises interesting questions about what makes species specialise in the first place. For some, it might not be the characteristics of the host plant that matter so much as the habitat that it provides, in which case some species will be more robust to climate change than they first appear.

Whether butterflies can actually evolve to cope with climate change, as opposed to changing their habits and habitats, is another question. “We know that evolution can happen rapidly if selection pressure is strong enough, and we have lots of examples in insects, so the expectation is that butterflies should be able to,” says Joel Kingsolver at the University of North Carolina at Chapel Hill.

This is difficult to demonstrate because you need to look at traits over time, and that requires data from experiments carried out in previous decades to compare with data from today. But Kingsolver and his colleagues have done that on several occasions in their work with sulphur butterflies in the Rocky mountains in North America. Earlier this year, they recreated an experiment from 1971 that looked at pigmentation in adult wings. They found that over the past 47 years, these butterflies have not only evolved lighter wings, but also the ability to calibrate wing colour in response to the temperature during their pupal stage – both of which are known to have fitness advantages in a warming world. “So that trait has evolved, and the plasticity too,” says Kingsolver.

Climactic lag

That isn’t to say that butterflies will always evolve fast enough to keep pace with the effects of climate change, saving species or populations that would otherwise go extinct. “I’m kind of dubious about that,” says Kingsolver. But if it happens at all, it will be in species that can reproduce quickly, he says.

Overall, what we are learning from how butterflies are responding to the first throes of climate change is that generalists, those species that aren’t fussy about habitats and host plants, are best suited to adjust in the short-term – and especially those that can reproduce more than once a year. Specialists, meanwhile, will suffer as climate change shifts their life cycles out of sync with the plants and habitats on which they rely, even if some may be able to find new microhabitats.

Ultimately, the result is likely to be what Anne Magurran at the University of St Andrews in the UK has dubbed the “shopping mall” effect. Just as shopping malls and high streets are losing distinct, independent shops while a few chain stores dominate everywhere, so ecosystems that previously hosted all manner of species will look more and more homogenous. “We end up with increasing populations of common and widespread species, but lose treasured rarities,” says Hoare.

In the long term, even the generalists may not be able to adapt quickly enough to keep pace with climate change. Researchers are already observing a gap, known as “climactic lag”, between where species should be if they were tracking rising temperatures and where they actually are, geograpically speaking. One key reason they are falling behind is because there is little suitable habitat to host them.

The best thing we can do, beyond drastically reducing carbon emissions to slow the pace of global warming, is to make sure we preserve and expand a diverse range of nature reserves. This will help provide a range of habitats for those species that are able to quickly up sticks and shift towards the poles. “The only response,” says Hoare, “is to build large, robust networks of habitats with lots of variety that run through fragmented landscapes, and let butterflies find their way.” ▮

Madeleine Finlay is a science writer based in London

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What makes a criminal?

Terrie Moffitt investigates whether there is such a thing as a criminal mind, and whether adolescent delinquency forecasts a life of crime. Now, after decades of grappling with these big questions, she has some answers, she tells Dan Jones

ROCIO MONTOYA

OUR attitudes towards crime and punishment are highly political. They often come down to how much we believe a person's particular life circumstances should be taken into account when deciding whether their punishment fits the crime they committed. But criminal justice isn't an evidence-free zone. Behavioural scientist Terrie Moffitt at King's College London has spent her career trying to uncover biological and environmental roots to criminal behaviour. Now she has evidence from brain imaging and genetics to support her idea that there are generally two groups of people who commit crime, each with different causes for their behaviour and different prospects for reform.

Dan Jones: How has the nature-nurture debate influenced views on criminal behaviour?

Terrie Moffitt: Our thinking about the roots of antisocial behaviour has followed pendulum swings between putting nature or nurture centre stage. Writing in the late 17th century, philosopher John Locke came down on the side of nurture, arguing that we are born as blank slates and learn all our behaviours, bad ones included. Then in the 19th century, Cesare Lombroso, the founder of criminology, suggested that bad people were born that way and could be identified by the shape of their eyes, ears, teeth and eyebrows. By the 1960s, after John Watson and B. F. Skinner developed behaviourism, the pendulum had swung back to nurture.

Everything changed in the 1980s and 90s, and the debates really heated up. Scientists started reporting studies of crime drawing on thousands of twins and adoptees in Scandinavian registers, which seemed to point to genetic transmission of criminal behaviour from parent to child. This was like pouring petrol on a fire, and the nature-nurture debate got vicious. But these studies also made clear that over half the variation in antisocial and criminal behaviour couldn't be explained by genetics, and provided some of the first really solid evidence for the social transmission of crime in families. Since then, nearly everyone has come to agree that crime involves both nature and nurture.

But you think they have been missing something. Can you explain what?

Back in the early 1990s, criminologists knew that male antisocial behaviour is concentrated in adolescence: when you plot crime against age, you get a crime curve that peaks between 16 and 20 years of age, and tapers off into the thirties and forties. They also knew that fewer than 10 per cent of males commit more than 50 per cent of crimes.

In 1993, I published a hypothesis that the peak of the crime curve conceals two different groups, with different causes for their criminal behaviour. I called one group "life-course persistent offenders". These are people who show extreme and often violent antisocial behaviour that begins in early childhood and continues through adulthood. I thought they would be a minority, at less than 10 per cent, and biological factors along with bad childhoods would play a big role for them. The other group, which I called "adolescence-limited delinquents", show a similar level of antisocial behaviour when they are around 18 years old but grow out of it. I suggested that biology wasn't part of the story for this group. And I expected them to be very common, with teenagers who abstain from offending altogether being the rare ones.

How do you go about testing an idea like this?

You need to follow people for years to identify life-course persistent and adolescence-limited criminals, ideally from birth to

›

"Societies haven't put as much into rehabilitation programmes as we have invested in prisons"

their fifties, measuring antisocial behaviours all along the way. We have been able to do this in the Dunedin Cohort Study, which has followed 1000 New Zealanders from their birth in 1972/73 and who are now in their late forties. And in the past few years, we have used brain imaging and new techniques of whole-genome analysis to look deeper into the biology of crime.

What have you discovered from the brains studies?

When we scanned the brains of the Dunedin study members last year, we found that most of those who were offenders didn't have unusual brains. But people whose antisocial behaviour started in childhood and persisted into adulthood – the life-course persistent group – showed less grey matter in some regions of the cortex, most of which have previously been linked to antisocial behaviour through their involvement in goal-directed behaviour, regulation of emotions and motivation.

Are you saying these people were born with different brains?

It is difficult to say. Had we done the scans when they were small children, we could say whether the brain-structure abnormalities were there before their lives of crime, but the technology wasn't available then. More recent brain imaging of children with callous or unemotional kinds of behaviour – children who hurt other children and apparently lack remorse – has revealed similar brain abnormalities to those we are finding.

So it is possible for such brain-structure abnormalities to have been there all along. The persistent offenders in our study also tended to have bad childhoods, which might alter brain development. That muddies the picture.

What have you discovered about genetics and criminality?

In the past decade, new technology has emerged to allow us to simultaneously look at thousands of genetic variants across a person's whole genome, and link genetic markers with specific behaviours. It is hard to do this directly for crime because you need huge samples of hundreds of thousands of people that you can divide into persistent and adolescence-limited offenders. You can't just ask people about their early life behaviour as people's memories are too unreliable. And there are no long-term studies tracking this number of people.

So we have turned to other measures, like educational attainment, which has been linked to crime and which most people can and will report when they sign up to services like 23&Me or Ancestry.com. We have used this kind of anonymised genomic data to create what is called a polygenic score for educational attainment, which tots up how many genetic markers known to predict success in education a person has. In our Dunedin study, we found that people who had shown antisocial behaviour that began in childhood and persisted right through adulthood had low polygenic scores – but, just like in the brain-imaging study, these persistent offenders also had bad childhoods.

Might such genes influence criminal behaviour?

Most people with a low polygenic score for educational attainment struggle with self-control all their lives. We have shown that they also tend to start talking late as toddlers, don't use language very well, have difficulty learning to read, have trouble concentrating and controlling their thoughts and struggle to remember facts and figures. So they find school really frustrating and humiliating, and leave it as soon as they can. If they lack qualifications when it comes time to find a job, crime may be their best option.

And if you are good at crime, it brings a lot more self-esteem than school does.

JAMIE MANN/ALAMY

Are some people destined for a life of crime?

No. People will turn out just fine as long as they have good parents who provide warm, sensitive, stimulating parenting and lots of consistent, loving discipline, plus the necessary resources for child development, such as nutritious food and encouragement at school. But great childhoods can be in short supply. Deprivation, abuse and neglect allow a child's own personal vulnerability to grow into antisocial and criminal behaviour.

If a small minority of people is biologically predisposed to antisocial behaviour, why is delinquency in adolescence so common?

Adolescence is a tricky time. Many adolescents feel that they have to prove to themselves and other kids that they aren't babies any more, and what better way to do this than to commit a few risky crimes?

But most people don't really like to live way out on the edge all the time, and as soon as adolescents enter adulthood, the delinquent lifestyle loses a lot of its appeal. For young people who had warm family relationships, good school grades and clear heads before they became teenagers, it is fairly easy to wake up and walk away from offending – if they have managed to avoid a criminal record.

Most young offenders won't carry on into a life of crime – but having a criminal record can harm chances of reform

How do you explain the rare adolescents who never choose to transgress?

I originally thought crime was so normal that there must be something unusual about teenagers who abstained, something that cut them off from other people their age. Perhaps they were unpopular, intensely shy, highly anxious or belonged to very strict religious communities.

Here, my ideas haven't stood the test of time very well, because these factors don't account for many abstainers. I seriously underestimated the extent to which many happy, healthy, popular young people just don't want to break the law. It seems likely that in the past, abstainers were more likely to be social outcasts, but somehow adolescent culture has changed.

Have your ideas been picked up by the criminal justice system?

It is a long path from the ivory tower to policy circles. However, my theory has been cited in policy documents, including the 2016 modern crime prevention strategy from the UK's Home Office, and several National Research Council reports to governments in the US. Consistent with my research, these reports stress the need to distinguish between the few offenders who have adverse backgrounds and a poor prognosis and the many who have ordinary backgrounds and a better prognosis.

Until 2007, Britain had a policy called "all crimes brought to justice" that meant police officers were instructed to arrest any juvenile offender who came to their attention and charge almost all of them forwards to the courts. Today, policing policy has radically changed, and police officers in Britain have the discretion to divert many young offenders away from the courts and the jails, which helps young people avoid a criminal record, gives them room to reform and helps them get employment. There is only a small group that needs to feel the full force of the law, a message that has got through to law enforcement.

Does that mean we should lock those people up for as long as possible?

This is the single most important question. At the moment, that is typically what has to happen to keep the public safe. But societies haven't put nearly as much energy into developing treatments and rehabilitation protocols for persistently antisocial people as we have invested in building prisons. And very little has been done on effective prevention programmes. Our work suggests that the path to persistent criminality begins in early childhood, which should be a good time to do something about it through interventions in schools and home life. There is ongoing work on prevention programmes, but it is early days.

Can science really change how societies deal with crimes and with the people who commit them?

Policy is determined by more than just evidence. Voters watch crime policy closely, so governments implement lenient or punitive crime policies according to whether their voter base is liberal or conservative. However, every so often, public opinion takes an about-face in reaction to a high-profile event, and that forces change. We are seeing this right now in the Black Lives Matter protests: there is a scramble over policing reform. ■

Dan Jones is a freelance journalist based in Brighton, UK. Follow him on Twitter @multipledraftz

It's easy to feel downbeat about climate change. But as climate scientist **Mark Maslin** told a recent *New Scientist* online event, there's so much governments, companies and all of us can do – and now is the time to do it

Climate change? Yes, we can.

New Scientist events

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IT MIGHT seem bizarre that I'm talking about climate change when we're all faced with a huge pandemic. But many of us believe that the bigger threat facing us is climate change. What I want to show is that by dealing with the impact of this pandemic, we can also deal with climate change. We can have win-win solutions.

The first thing to realise is that climate change science is really old. In 1856, the US scientist and feminist Eunice Foot took two glass tubes, put CO_2 in one and normal air in the other, stuck a thermometer in each and left them out in the sunshine. She saw the one with CO_2 heated up quicker, got hotter and stayed warmer for longer. It wasn't much later that in London John Tyndall measured the "radiation effect", the actual effect of heat absorption by gases in Earth's atmosphere.

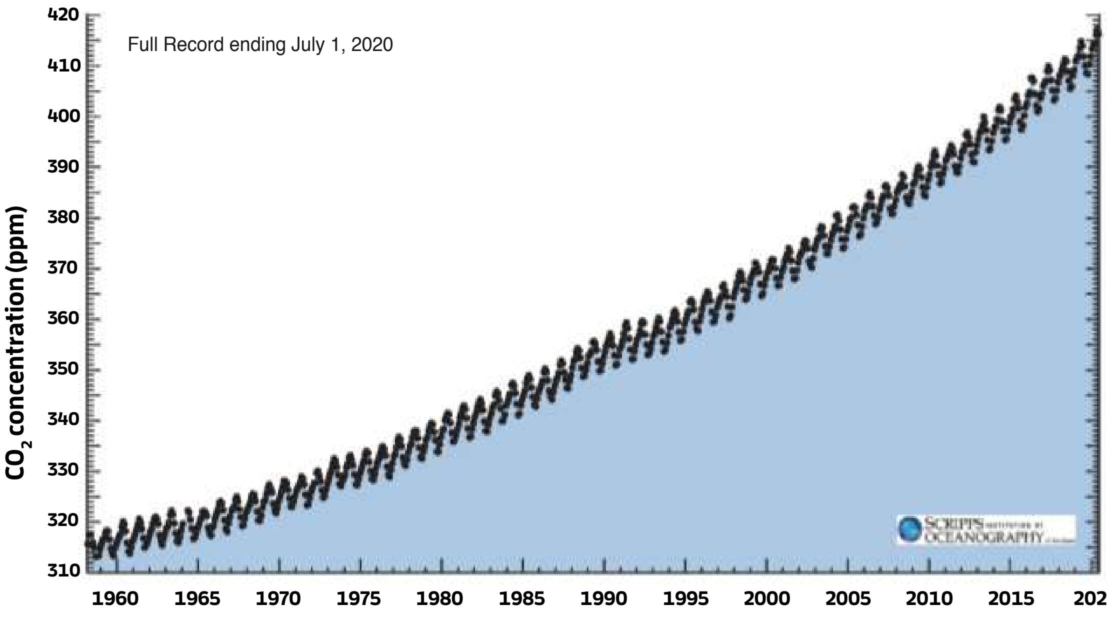
Just imagine you're not in lockdown, but on a tropical beach. You feel hot. Sunlight hits your skin and converts to heat. That's exactly what happens to Earth. As it radiates the sun's energy back into space as heat, greenhouse gases grab some of it, hold on to it for a while, and then release back it into the atmosphere. If you took all the greenhouse gases out of our atmosphere, the temperature would drop by 35 degrees. The English winter would be about minus 30 Celsius, and the English summer, if you're being generous, would be about minus 15. In that sense, greenhouse gases are a good thing.

But in 1938, the researcher Guy Callender looked at data from 147 weather stations around the world. He saw that the planet's temperature was rising, and was able to link that to increased CO_2 due to industrial processes. The famous Keeling Curve, which measures CO_2 in the atmosphere from Mauna Loa on Hawaii, shows the trend since (see diagram, below). It goes up and down every year with the seasons, but it just keeps on going up. It's peaked so far in 2020 at 417 parts per million. That's an increase of 45 per cent since the industrial revolution, and the highest level for at least the past 3 million years. We know that thanks to beautiful records from ice cores drilled from Antarctica and Greenland, which have ancient air trapped in them. You can measure how much CO_2 and methane is in there, and it goes up and down beautifully with the ice ages – until the past 150 years.

And we're seeing the effects. In the Arctic, we have half the amount of summer sea ice that we did 40 years ago. Sea level is now 24 centimetres higher than before the industrial revolution, and the increase is accelerating. If you put data from NASA, the US National Oceanic and Atmospheric Administration and the UK Met Office together, they all show the same trend: 2016 is the warmest year on record, and 2019 the second. Even now, we think there is a 70 to 80 per cent chance that 2020 will be the warmest year yet. Check back in December to see if we were right.

Onwards and upwards

The Keeling curve measures the concentration of CO_2 in Earth's atmosphere – and it's been bending upwards ever since records began



SOURCE: SCRIPPS INSTITUTION OF OCEANOGRAPHY

There's only one Earth

What about the future? As a scientist, I want lots of Earths to experiment with, so I can change one thing, see what happens, then change another and see what happens. But we only have one Earth, so we have to cheat. We build computer models to run multiple experiments on Earth's climate, so we can look at what the future is going to look like under different scenarios. And you see that if we have no climate policies, that gives you 4 to 5.5 °C of warming by 2100; if we continue with current policies, it's 3.1 to 3.7 °C; and if we follow the pledges made at the 2015 Paris climate negotiations, we could keep it down to 2.6 to 3.1 °C. And then there two other magical, aspirational pathways to keep the temperature rise down to 2 °C or 1.5 °C.

We can also look at specific questions like how often we will have summer heatwaves like the ones we experienced in 2003 and 2018 under these different scenarios. The 2003 heatwave was the worst to have hit Europe so far, with about 70,000 excess deaths in northern Europe. If you look at French death rates over the past 20 years, you see two noticeable peaks: one in 2020 for covid-19 and one in 2003. The excess deaths were about the same, with the peak higher in the heatwave, but less broad over time.

Will this become the new normal here in the UK? We can look at the summer of 2018, which was a truly global heatwave. We get the answer, on 1.5 °C pathway, one in four summers will be like that here; 2 °C, it's every other year; 3 °C, it will be nine in every 10 years. On top of that, there might be seasonal heatwaves as well. The winters in the UK are going to be warmer and wetter,

NASTCO/ISTOCK PHOTO

too, and rain will fall in more intense bursts, increasing flood risk particularly in big cities along the coasts – London, for example. There'll be more unexpected, short, sharp cold snaps, again with more flood risk when snows melt.

Similar things will probably happen in places where you wouldn't expect them from past climate. At the moment, 825 million people go to bed hungry every night, and over a billion people don't have a constant supply of fresh, safe water. Food and water insecurity could get worse with climate change, hence why many experts talk about possible increased migration and conflict.

But none of this is a given. The Paris Agreement was a landmark. It basically says that the whole world, 193 countries, will cut greenhouse emissions as close to zero as we can in the 21st century. If we want to keep the temperature rise to that aspiration of 1.5 °C, that's technically feasible, too, but we first need to cut global CO_2 emissions down to zero by 2050. What is rarely mentioned is we then have to suck CO_2 from the atmosphere, creating negative global emissions. How much depends on how fast we get to net zero.

Hasn't covid-19 helped us – hasn't stopping 100,000 flights a day, not using cars and so on made a big impact? Well, yes and no. The drop in daily emissions was quite large, about 17 per cent in April alone. But over all of 2020, we are looking at maybe a 4 to 7 per cent drop, meaning the same emissions in 2020 as in 2006. That's not going to save us, and we know from the financial crash in 2008 that the rebound effect is very quick.

This pandemic has taught us something: that even though all round the world, we weren't flying, we weren't travelling into work, we weren't using our cars, emissions were still incredibly high. That's because most of global emissions are due to energy production – what's powering your computer and my laptop to be able to give this talk.

So what can we do? I'll start with governments, because one thing we've rediscovered in this crisis is that it's governments, not companies, that look after us in a crisis. They can support renewable energy, that's a no-brainer, tax fossil fuels and cut fossil-fuel subsidies. The International Monetary Fund suggests that around the world every year, taking into account climate change damage, fossil-fuel subsidies are

Your climate questions answered

Mark Maslin also took questions from audience members after his talk. Here's a selection of the best

HOW CAN WE AVOID AN EXPLOSION OF GREENHOUSE GASES AS LOCKDOWNS END?

The International Energy Agency and International Monetary Fund just published a report saying this is the point where we have to make choices. And because emissions have already dropped, if we can keep them lower we're already on the route to net-zero carbon. The key thing is for governments to take the lead in the post-covid recovery, to incentivise companies and us as individuals to produce less emissions. The key is energy production. If we can shift it away from fossil fuels everywhere, and more towards wind, solar and tidal, then we can start shifting the whole thing.

HOW CAN WE EXTRACT CO_2 FROM THE ATMOSPHERE?

We have these amazing plants called trees that suck huge amounts of carbon dioxide from the atmosphere. We have cut down 3 trillion trees since the beginning of agriculture about 10,000 years ago, half of the trees on the planet. So we know that we can rewind and replant forests all over the world – and it's not as difficult as we think. Even though Earth's population is increasing, and will probably only stabilise at about 10 billion people in around 2050, people are moving to the cities, so we actually have more wild places where we can plant forests. If we start now, we have 30 years to plant more and more trees so that sucking CO_2 out of the atmosphere occurs in the second half of the century.

DOES NUCLEAR POWER HAVE ANY PLACE IN ALL THIS?

If you happen to be a country that already has nuclear power, that's brilliant, it gives you a low carbon footprint while it's operating. But it actually has quite a large lifetime carbon footprint when you consider factors such as building the plants and storing nuclear waste. Meanwhile renewable energy has improved so much that it is much cheaper than nuclear. When I started giving these sorts of talks, solar panels were 10 per cent efficient at converting sunlight to energy. Now they're nearly at 25 per cent. A leaf on a tree is at I per cent. We're nearly 25 times better at this now than trees are.

HOW CAN WE CRYSTALLISE IMMEDIATE CLIMATE ACTION?

I think what we have failed to do is provide this positive vision of the future. So often, climate change deniers have tried to paint climate action as if we're all going to go back and live in tents back in the wilds. That's not true. We're going to use technology to make sure that the world is a much better place. We're looking at 2050 as a time when there are 10 billion people on the planet, we've stabilised the climates, and we've actually allowed nature to grow back. Pandemics, whether it's SARS, MERS, bird flu or now coronavirus, have come about because we did not respect the boundary between nature and humans. This is the moment to re-evaluate our relationship with nature.

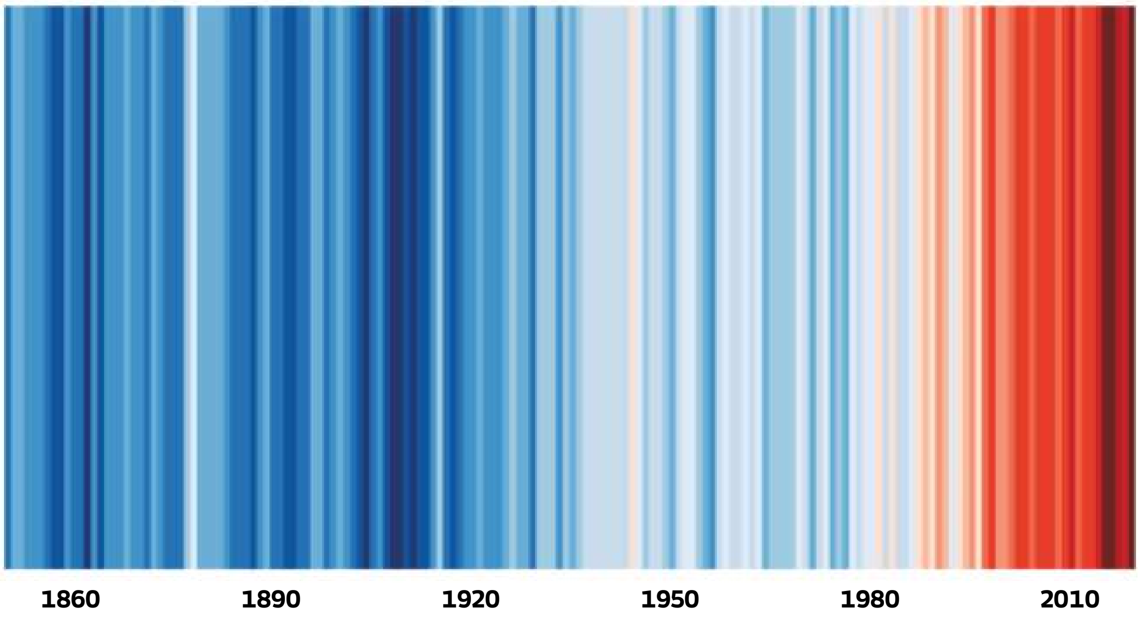
DO YOU REALLY THINK ACTION CAN SUCCEED?

The really exciting thing is that our children are a completely different species. They can interact with social media, they have no idea of a world without Google, they are really good at sifting through information and understanding what they trust and who share their values. For me, the new generation coming through gets the science, understands there can be a brilliant future, and knows we've got the technology to make it happen. They love technology. As long as we leave them a world in which we have already taken meaningful action to deal with climate change, they can build upon it and I think we're going to be sorted.

Want to see Mark Maslin's full talk?
Sign up for the event on-demand, including exclusive access to additional *New Scientist* content at newscientist.com/events

Showing the stripes

Climate scientist Ed Hawkins's graphical representation of the increase in average global temperatures as a result of rising CO_2 levels has become an unlikely fashion icon



ED HAWKINS (UNIVERSITY OF READING) SHOWYOURSTRIPES.INFO

about $5 trillion a year, twice the UK's GDP.

We can support electric cars and the move to public transport, and also build and support carbon neutral buildings and retrofit existing buildings. We can rewild, plant lots of trees and make sure wetlands are safe and expand, so we can pull lots of CO_2 out of the atmosphere and make getting to net zero much easier. We can promote low emission farming and diets, and support and expand the emission trading schemes that are burgeoning around the world.

People also don't realise how much the green economy is worth. It's easy to say how much oil is produced, and how much money that makes, but because the green economy is so dispersed, it's very difficult to do. Lucien Georgeson, a brilliant PhD student of mine now at the University of Oxford, worked out that the global green economy is worth about $10 trillion per year. That's four times UK GDP, and it's growing at 10 per cent a year. If Donald Trump wanted to become the greatest jobs president ever, he should have been investing in the green economy.

As for companies themselves, they too can switch to 100 per cent renewable energy, use carbon neutral buildings, retrofit buildings, and offset emissions through reforestation and rewilding, and make sure their supply chains do too. Most importantly, they can lobby governments to support the change they actually want. Being sustainable and actively caring about the environment turns out to be good for business: the Carbon Disclosure Project shows that companies reporting their carbon impact get a 67 per cent higher return than companies that refuse to.

> **"The battle against climate change will be won or lost with the post-covid-19 recovery"**

We can also drive all this through individual climate actions, and act how we want companies and governments to. The first thing is talking. Climate change is the greatest threat to humanity, we can't say, let's not talk about it, it's a bit too scary, it's not nice. We should be screaming about this on social media, and talking about how we going to actually save our planet for ourselves.

How? Well, we can switch to a more vegetarian or vegan diet. That improves our health and our children's health, and at the same time massively reduces our food carbon footprint – a real win-win. We can switch to a renewable energy supply at home, and so send a message to energy suppliers that we only want renewable energy. We can reduce waste, reuse, recycle more – we all know the mantra. If you don't need a car, cycle or use public transport – wearing a face mask, of course. If you need a car, then guess what, have electric or hybrid one. Stop flying, or if you must because, offset your emissions.

In fact, offset your unavoidable emissions at 10 times the amount, just to make sure they are covered. If you have a pension plan, make sure your pension company divests from fossil fuels. If they don't, move your pension. If you are lucky enough to have investments, invest in things that are going to make a bigger profit: the green economy.

And protest. The world has been changed by young people. Schoolchildren have decided to take a Friday off every month and go and protest, and it's been incredible. Something like four and a half million young people protested on one Friday to show that they thought that adults have mucked it up and it really should be sorted out before they are adults. And voting, voting: if you're lucky enough to be in a democratic country, that is a powerful tool to say, I'm sorry, we want you to deal with climate change.

For me, the battle against climate change will be won or lost with the post-covid-19 recovery. Governments have started to lend companies a huge amount of money. Some are saying, you can have this money only if you do X, Y and Z to reduce your carbon footprint. So let's do all this and more. There are so many great ideas out there. We can rebuild our economies to be more resilient against the second and third waves of covid-19, and against future pandemics – and while we do, we can sort out climate change, too. ▮

Mark Maslin is professor of climatology at University College London and author of books including *Climate Change: A Very Short Introduction* and *The Human Planet: How we created the Anthropocene* with Simon Lewis. This is an edited version of a talk he gave at a *New Scientist* online event on 18 June 2020

How good is your memory?

Test five different memory skills with this quiz from the *New Scientist* book, *The Brain: A user's guide*. Make sure you have a stopwatch and blank paper handy, study each problem for the requisite time, then close the magazine and write down what you can recall. No cheating!

1. Language

Take four minutes to learn the following ten words from the Basque language. Then turn over this page and write them out, with their English equivalent. You get one point per correct answer.

English	Basque
white	zuri
today	gaur
seven	zazpi
leg	hanka
cheese	gazta
hello	kaixo
house	etxea
bed	ohe
cold	hotza
apple	sagar

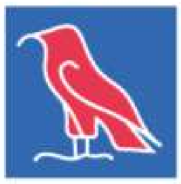
2. Names

Between March 1797 and April 1865, there were 15 different US presidents. You have five minutes to learn the sequence. Score one point per correct name in the correct place.

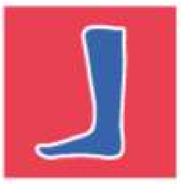
1 John Adams
2 Thomas Jefferson
3 James Madison
4 James Monroe
5 John Quincy Adams
6 Andrew Jackson
7 Martin Van Buren
8 William Henry Harrison
9 John Tyler
10 James Polk
11 Zachary Taylor
12 Millard Fillmore
13 Franklin Pierce
14 James Buchanan
15 Abraham Lincoln

3. Signs

You have two minutes to learn the Egyptian hieroglyphic symbols for the following letters. Score one point for each correct symbol.



A



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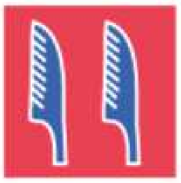
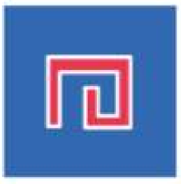


Y



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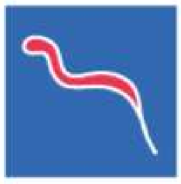
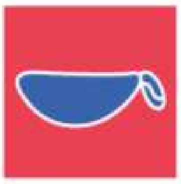
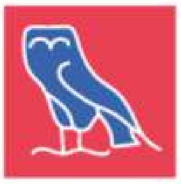


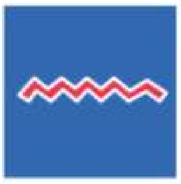
J



K



M



N

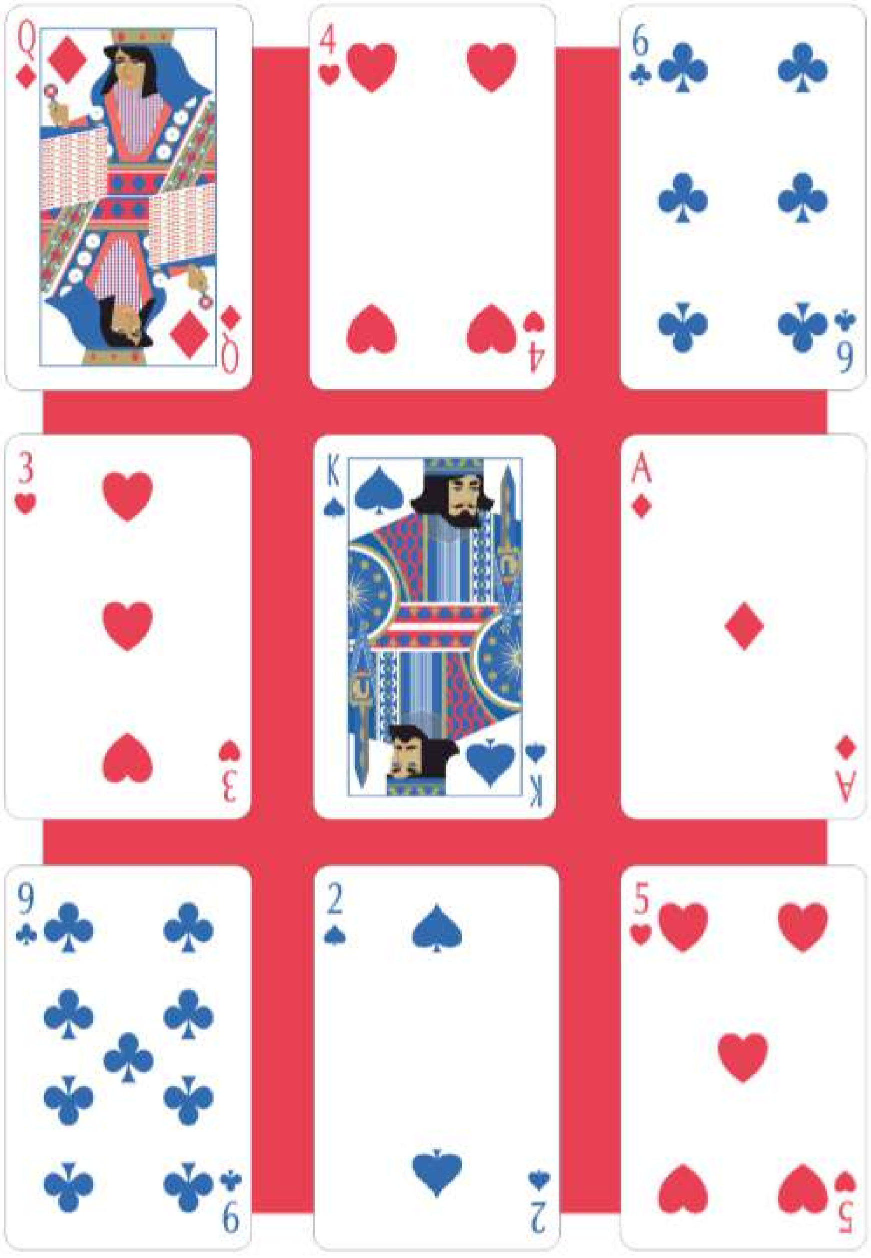
4. Numbers

Give yourself three minutes to learn the following sequence of 20 digits. Then write down as many as you remember in the correct sequence. You get one mark for each correct answer, up until the point where you make a mistake.

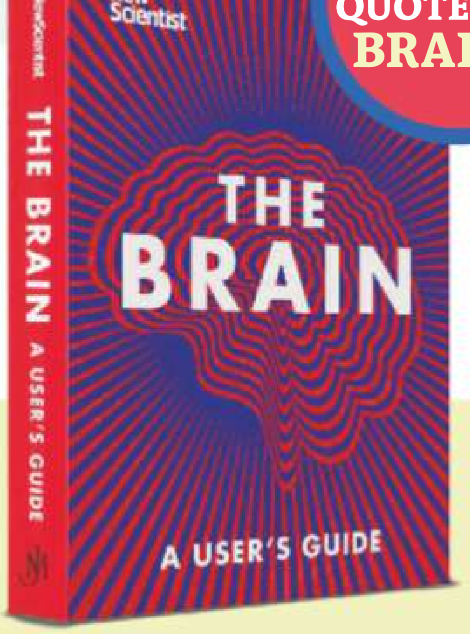
7	3	6	6	1	0	7	2	4	8
2	0	6	5	1	8	4	7	0	2

5. Playing cards

You have two minutes to learn the following nine playing cards, plus their position. Score one point for each card remembered, in the correct location.



MOANA AKASSO/EVGENII_BOBROV/PAVLEN/ISTOCK PHOTO



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Here are the average scores for *New Scientist* employees. Did you beat them?

1 Language: 7/10, **2** Names: 12/15, **3** Signs: 7/8
4 Numbers: 14/20, **5** Cards: 8/9

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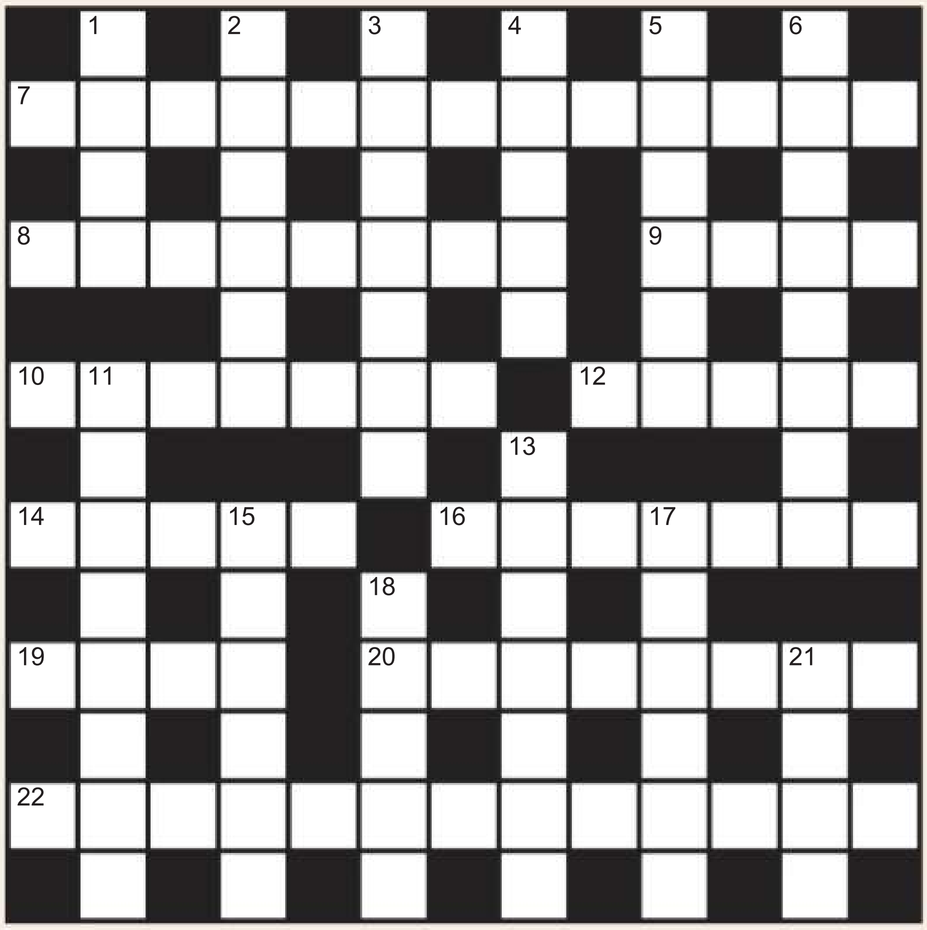
Puzzle
What is so special about the digits of my prime number? p54

Cartoons
Life through the lens of Tom Gauld and Twisteddoodles p54

Feedback
A makeover mishap for the Virgin Mary p55

The last word
Why do some birds bob their heads as they walk? p56

Cryptic crossword #35 *Set by Sparticle*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Swathes rodent cut through Scottish bread, say? (5,3,5)
8 Áine, according to doctors, immediately was in her element (8)
9 Alsatian evenly stretched out (4)
10 "Boffin drive" attracts CEO (7)
12 That man rolls his tongue in one's ear to form a spiral (5)
14 Los Angeles studio's top hospital drama showcasing tool for eye surgery (5)
16 Machine component frequently rapped to indicate excellence (7)
19 Chemically concealed mineral (4)
20 Folded so, indeed like a Möbius strip (3-5)
22 A rage incurred after damaging frame (13)

DOWN

1 Exclamation of surprise meeting female resistance units (4)
2 Quietly get to spread the word of god (6)
3 Supreme precept a literate leader follows (7)
4 Summer reptile (5)
5 Prime it weekly, in view of how many months there are (6)
6 Envenomed iciness extracted by therapy (8)
11 Pass on donation to cover transition (8)
13 Job prospects take a bumpy journey south (7)
15 The nameless contents of coat (6)
17 Open-ended register containing Northern Irish treatment centre (6)
18 Bacteria can only cause cancer in small amounts (5)
21 Trimmed hedges found around a square, say (4)

Quick quiz #59

1 Pluto lost its status as the solar system's outermost planet in 1979. Why?

2 A carbonated form of hydroxyapatite, a calcium phosphate mineral, makes up 70 per cent by weight of your what?

3 Space scientist George Carruthers invented what sort of camera, which monitored Earth's upper atmosphere for signs of pollution from the moon during the Apollo 16 mission in 1972?

4 What shaped nose might you expect of *Tursiops truncatus*?

5 In the general taxonomic classification, what rank comes above a genus and below an order?

Answers on page 54

Quick Crossword #61

Answers

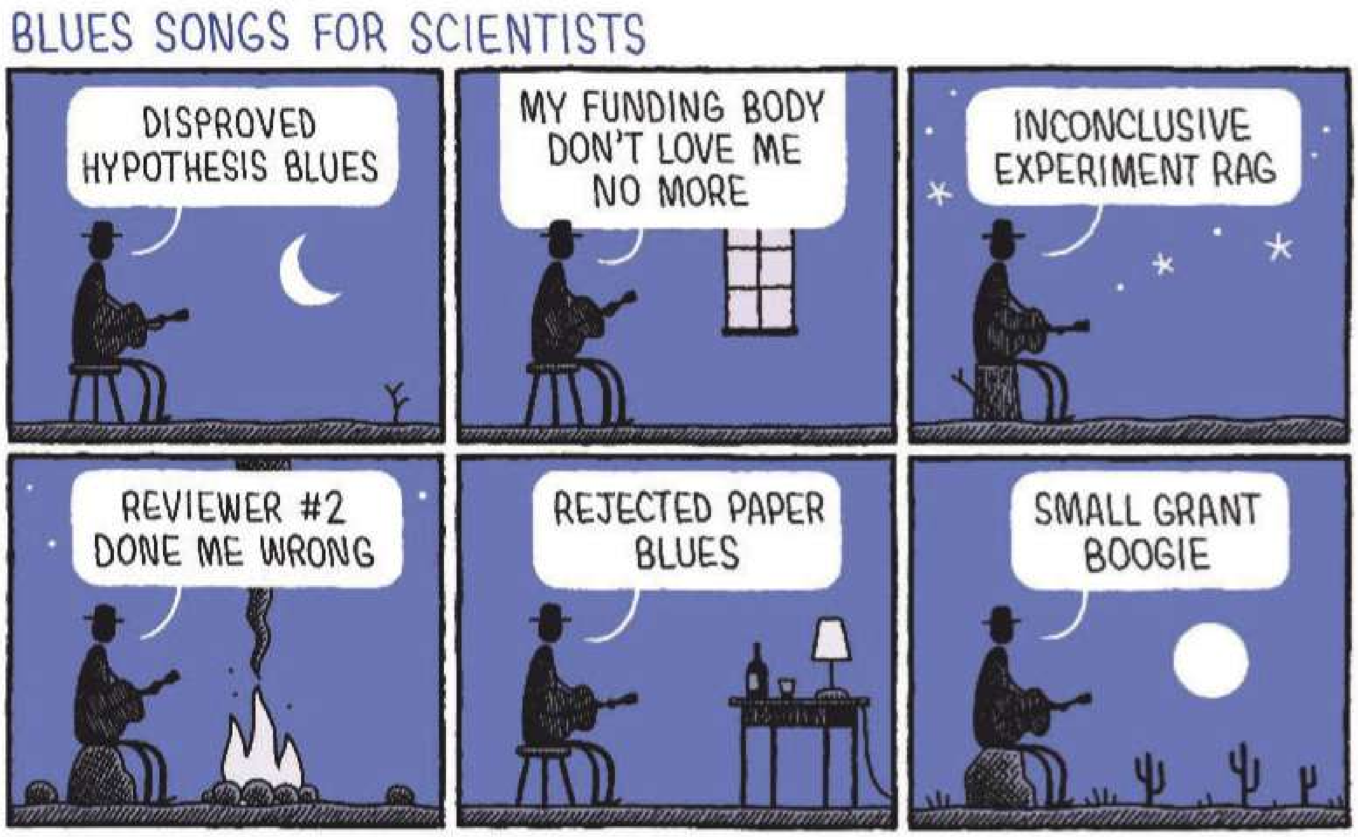
ACROSS **8/11** Yellow flag, **9** Emotions, **10** Smoking gun, **12** Tissue, **13** Intranet, **14** Chomsky, **16** Pontiac, **20** White-hot, **23** Expire, **25** Snow, **26** Barbarella, **27** Carriage, **28** Aweigh

DOWN **1** Heimlich, **2** Flukes, **3** Swan neck, **4** Penguin, **5** Botnet, **6** Diffract, **7** Intake, **15** Math wars, **17** Omega Man, **18** Agrology, **19** Starter, **21** Hangar, **22** Hubcap, **24** Pre-med

Our crosswords are now solvable online
newscientist.com/crosswords

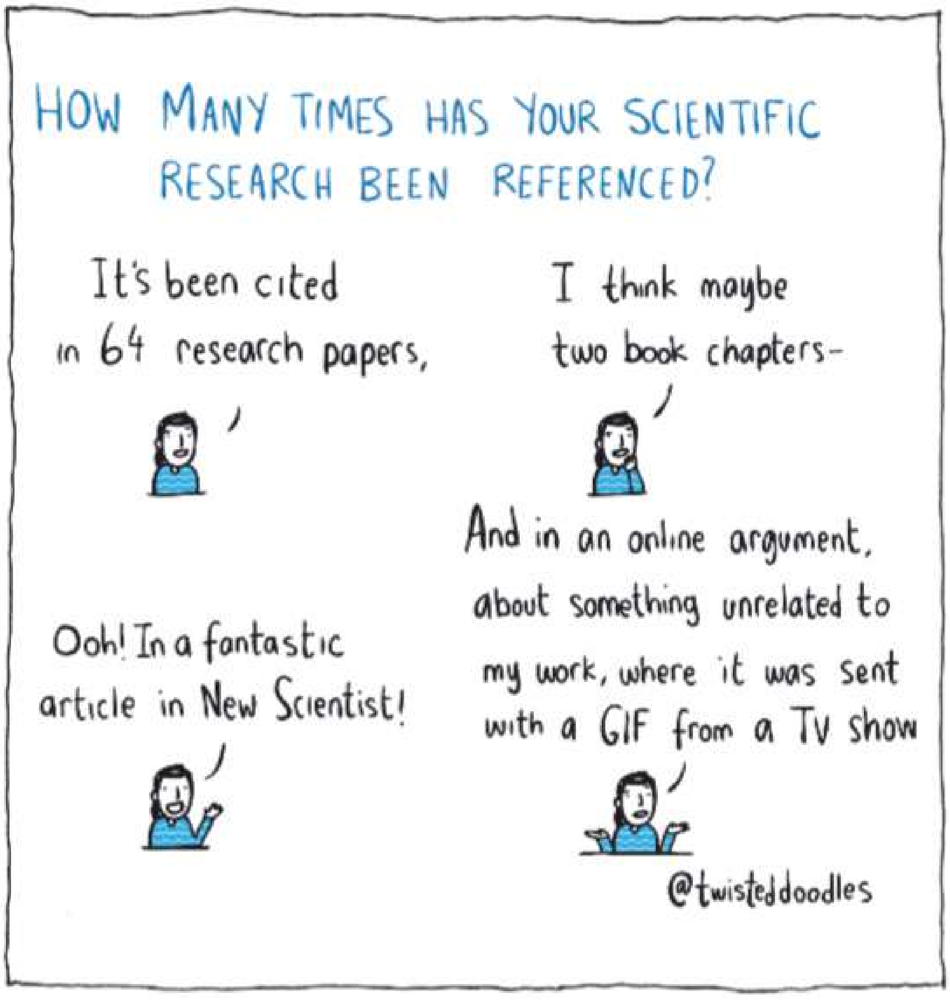
Tom Gauld

for New Scientist


BLUES SONGS FOR SCIENTISTS
DISPROVED HYPOTHESIS BLUES
MY FUNDING BODY DON'T LOVE ME NO MORE
INCONCLUSIVE EXPERIMENT RAG
REVIEWER #2 DONE ME WRONG
REJECTED PAPER BLUES
SMALL GRANT BOOGIE

Twisteddoodles

for New Scientist


HOW MANY TIMES HAS YOUR SCIENTIFIC RESEARCH BEEN REFERENCED?
It's been cited in 64 research papers,
I think maybe two book chapters-
And in an online argument, about something unrelated to my work, where it was sent with a GIF from a TV show
Ooh! In a fantastic article in New Scientist!
@twisteddoodles

Quick quiz #59

Answers

1 Its highly elliptical orbit passed within that of Neptune's, where it stayed until 1999. It was formally demoted to a dwarf planet in 2006

2 Bones

3 An ultraviolet camera, or spectrograph

4 Bottle, although it is more like a beak; it belongs to the common bottlenose dolphin

5 A family

Puzzle

set by Will Taylor

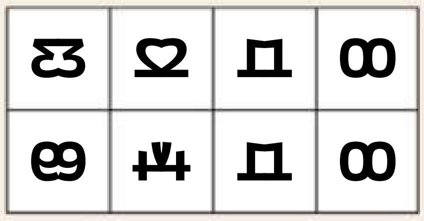
#67 My prime

I am thinking of a two-digit prime number. The special thing about my prime, though, is that if I square its two digits, the difference between these square numbers is also prime.

As it happens, I haven't given you enough information to identify my number. But whatever my number is, you can be certain that its two digits have a particular relationship to each other. What is that relationship?

Answer next week

#66 Square tiles



Solution

Each symbol is a number and its mirror image. The numbers in the set are 0, 0, 1, 1, 2, 3, 4 and what looks like 6. The top row can be 3, 2, 1 and 0, and the bottom could be 6, 4, 1 and 0, but there is no simple rule for getting from the top number to the number beneath it (the first two numbers double, while the second two are the same).

But things are clearer once you realise that the "6" tile might actually be upside down, making it a 9. The numbers on the bottom row (9, 4, 1 and 0) are therefore the squares of the numbers on the top row (3, 2, 1 and 0).

The effrontery

These are tense times for businesses. With so much uncertainty about the coming months, it is little wonder that many organisations are diversifying, branching out and adding strings to bows that were previously left unstrung. Which is why we applaud investment bank Goldman Sachs for thinking about the long-term stability of its organisation and launching its own font.

That's according to The Verge, at least, which recently reported on the bank's surprising pivot to digital calligraphy. Dubbed Goldman Sans, French for Goldman without, the name has a certain succinct oxymoronicity that we at Feedback find refreshing.

But the news doesn't end there. The font, which resembles a sort of socially distanced Calibri with oddly flaccid lower-case 'l's, is free for all to employ, provided it isn't used to disparage Goldman Sachs. Forgive us while we make a quick call to our art editor to double-check what font *New Scientist* uses these days...

JOSIE FORD

Got a story for Feedback?

Send it to feedback@newscientist.com or
New Scientist, 25 Bedford Street, London WC2E 9ES
Consideration of items sent in the post will be delayed

Pi-eyed

Our thanks to Perry Bebbington for picking up the gauntlet Feedback threw down some weeks ago, when reporting on a highly inefficient way of calculating the value of pi. We challenged readers to do the opposite: namely, to come up with a way of defining pi to more digits than are required in the definition itself (for instance, 22/7 gets you pi to three figures so doesn't quite do the job).

"You can represent pi precisely using only 2 digits," writes Perry. "All you have to do is set your number base to pi then pi itself becomes 10." That wins 12 points from us, Perry – sadly, we can't remember which number base that is supposed to be in.

Botchicelli

It happened again! The restoration of religious iconography doesn't ordinarily fall within Feedback's purview, but forget about that for a moment – it happened again! Eight years after a Spanish fresco of Jesus was restored by what we will politely call an enthusiastic amateur, a 17th-century painting of the Immaculate Conception has received the same treatment.

The saintly face of the Virgin Mary has been given an uncanny, emojified flatness, with her eyes – instead of looking upwards at her creator – pleading with the viewer to be rescued. *The Times* quoted a Spanish restoration specialist as saying that terrible restorations were "far more common than you might think". Oh goody – bring on the next one!

Back in time delivery

It has been a good long while since Feedback's attention was last directed towards absurdities generated by well-meaning algorithms in the retail industry, a drought we are now delighted has come to an end. A reader has contacted Feedback to let us know of the difficulties they encountered trying to order a canoe from Amazon. "The item is only in stock on the 4th July," writes the reader, "but if you choose Premium Delivery, they will start up the Time Machine and get it to you on the 1st of July!!" The cherry on the cake? The reader's name: Duncan Purchase.

Possibly improbable

Two weeks ago, to our lasting shame and chagrin, we used the nonsense phrase "more than probable" in describing a hypothetical event. Feedback correspondent Bob Mays is gentle but firm in his written reprimand.

"What numerical probability should I understand by that? How does it compare to my favourite 'quite possible'?" he asks. "Do we need a lookup table for all the words and phrases that describe a level of probability?"

That might be helpful, Bob, although it is less than certain (but quite possibly more than unlikely) that we might nonetheless reoffend.

Jargon busters

On the subject of verbal abuse, our metaphorical mailbags are idiomatically heaving with examples of words and phrases whose habitual misuse grates upon your ears. The epicentre of everyone's frustration appears to be the word epicentre, which appeared in practically every email we received.

This unanimity of annoyance reminds Feedback of how everybody in the world claims their least favourite word is moist, a statistically improbable result that makes us want to have a word with whoever is programming reality. But back to epicentre. As Larry Stoter rightly points out, the epicentre of an earthquake isn't the point at which it begins, but the spot on the planet's surface directly above it.

Valerie Stevens suggests that "journalists seem to think that an epicentre is a centre somehow more extreme and that this is a way of emphasising the concept of 'central'." I think you may have put your finger on the epinub of the problem here, Valerie – we will be having a word with the rest of the editorial staff as soon as possible.

Real GOATs

Thank you also to the many, many members of the nominative determinism brigade (we should print T-shirts) who wrote in to say that a 20 June article on how "Goat milk could make cheaper cancer drugs" featured lead researcher Goetz Laible. ▮

Written by Gilead Amit

PLAINPICTURE/CULTURA/ANGELA CAPPETTA

Why do duvet covers gobble up socks and clothes in the wash?

This week's new questions

Cover-up **When you wash a duvet cover, why does other washing end up in it?** ***John Baruch**, Bradford, West Yorkshire, UK*

On the nail **Germs must accumulate under our nails, but they rarely cause infections. Does a natural antibacterial protect the area?** ***Lyn Williams**, Neath, West Glamorgan, UK*

Bird walk

Some birds that walk, rather than hop, like pigeons and magpies, bob their heads backwards and forwards as they move. Why? As they are descended from dinosaurs, would two-legged ones like *Tyrannosaurus rex* have done the same?

Will Higgs
Gilsland, Northumberland, UK
The short answer is that this is more to do with vision in some birds.

A free-range chicken, for example, is constantly searching the ground in front of it for tiny insects and seeds. Visual acuity is lessened by movement, so what it is doing is keeping its head stable for vision purposes as it walks.

Many other birds do something similar, even off the ground. If you ever get a good view of a hovering kestrel, you will see that it keeps its head stationary by adjusting the position of its body.

Likewise, many familiar garden birds will keep their heads stable while perching on a windblown tree or telephone wire.

I don't know much about dinosaur anatomy, but they don't appear to have fed by pecking at small items, and they may not have had the extremely flexible necks and skull articulation of modern birds. Perhaps they might have bobbed their heads from side to side, like an owl, to gain 3D perspective?

John Davies
Lancaster, UK
Birds have evolved large eyes on either side of a small head. This gives them almost 360-degree vision, but their eyes are immobile in the skull, so they have a mobile neck.

In contrast, humans have evolved relatively small eyes with excellent mobility in a big head, that is relatively fixed on the trunk.

Brains need time to process the images that the eyes send, so an immobile image is better for spotting hazards or food. As we walk, we make tiny movements in our eyeballs known as saccades, moving them by tiny increments. After each movement, when the eye is still and fixed on an image we capture it. A bird cannot do this, and instead keeps the head still in space as the body walks forward, so that their head appears to bob.

It is a bit like a dancer doing a pirouette – they quickly turn their head ahead of the body, then hold the head fixed as they complete the turn. This is done to avoid losing balance, as spinning of the head without pause confuses the semi-circular canals in their inner ear.

Tony Budd
Wickford, Essex, UK
I have always assumed that any bird with eyes orientated at roughly 180 degrees to each other can't have 3D vision of the sort that the brain produces from forward-facing eyes where the two visual fields partially overlap. But moving the head in a jerky fashion would also allow successive stationary "exposures" to be superimposed by the brain to generate the 3D image needed to properly assess the surroundings.

This is similar to the method used in 3D aerial photogrammetry where successive images taken from above are partially overlapped to give a 3D image of terrain.

Chance win

My son always beats me at Monopoly. Can a better understanding of mathematics and probability help me win?

Mike Follows
Sutton Coldfield, West Midlands, UK
Understanding the statistics of the game may help with strategy.

For example, saving money is pointless because it can't earn interest. It is better to buy properties as quickly as possible as this is the main way to generate income in the game.

Players should add houses and hotels as soon as they can, with the third house providing the biggest boost in income. Buying utilities like railway stations can offer a fast return on investment short-term.

Perhaps becoming more familiar with the rules might help too. For example, who knew that when players don't buy a property they land on, it should be auctioned for other players to buy?

What you do with all this information might depend on the age of your opponents. After all, young children love to beat their parents.

There is also a website by someone called Truman Collins describing the payback times for all the properties, including with various numbers of houses and hotels. This shows that owning and developing some properties is likely to be more lucrative than others, but, of course, players cannot guarantee being able to purchase these during a game.

However, be warned that consulting this site or a similar one by mathematician Tim Darling during a game might be seen as unethical and could lead to a family squabble.

Henrietta Sushames
Wellington, New Zealand
The best strategy for Monopoly is to borrow to buy as much as you can and get multiple houses on properties as soon as possible.

Adults are disadvantaged by responsibilities, which limit the time they can spend on the game, and empathy, which prevents the cold ruthlessness required to win and gloat.

My advice would be to work on procrastination and selfishness instead of maths. ▮

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